

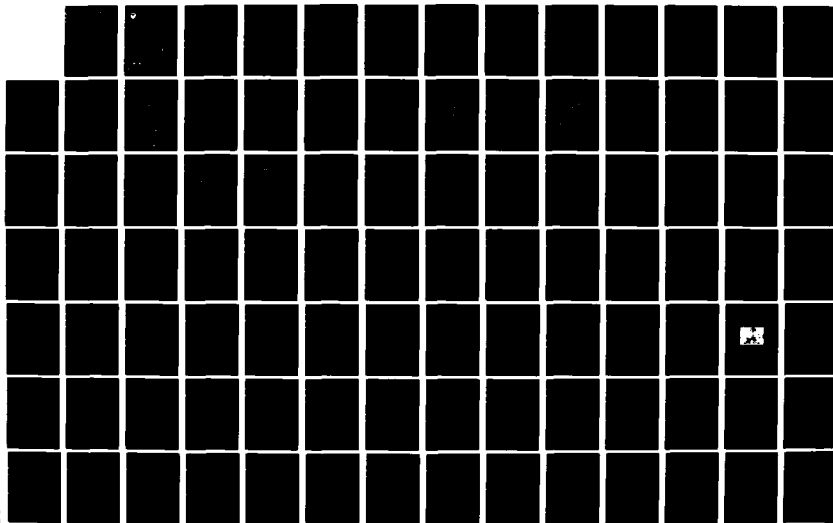
AD-A128 788

MANUFACTURING METHODS AND TECHNOLOGY PROGRAM FOR
RUGGEDIZED TACTICAL FIBER (U) ITT ELECTRO-OPTICAL
PRODUCTS DIV ROANOKE VA D TAYLOR OCT 81 ITT-81-42-05A
CORADCOM-79-0789-7A DAK80-79-C-0789 F/G 13/8

1/2

UNCLASSIFIED

NL

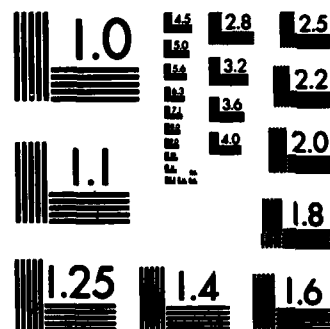




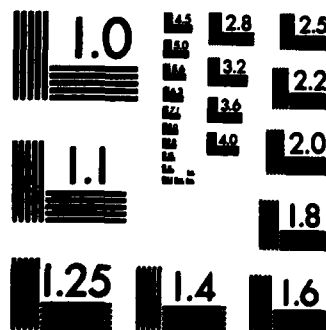
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



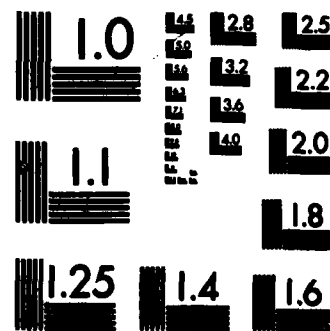
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ADA 120780



(12)

RESEARCH AND DEVELOPMENT TECHNICAL REPORT
CORADCOM- 79-0789-7A

MANUFACTURING METHODS AND TECHNOLOGY PROGRAM
FOR RUGGEDIZED TACTICAL FIBER OPTIC CABLE

D. TAYLOR

EEP ELECTRO-OPTICAL PRODUCTS DIVISION
7835 Plantation Rd., Roanoke, Va. 24019. Telephone (703) 563-0371

SEVENTH PROGRESS REPORT
FOR PERIOD
JULY 1981 - SEPT 1981

DTIC
ELECTRONIC
S OCT 27 1982

APPROVED FOR PUBLIC RELEASE ; DISTRIBUTION UNLIMITED

CORADCOM
US ARMY COMMUNICATION RESEARCH & DEVELOPMENT COMMAND
FORT MONMOUTH, NEW JERSEY 07703

DTIC FILE COPY

82 10 27 012

DISCLAIMER STATEMENT

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

DEPOSITION INSTRUCTIONS

Destroy this report when it is no longer needed. Do not return it to the originator.

ACKNOWLEDGEMENT STATEMENT

This project has been accomplished as part of the U.S. Army Manufacturing Methods and Technology Program which has as its objective the timely establishment of manufacturing processes, techniques, or equipment to insure the efficient production of current or future defense programs.

**MANUFACTURING METHODS AND TECHNOLOGY PROGRAM
FOR RUGGEDIZED TACTICAL FIBER OPTIC CABLE
SEVENTH PROGRESS REPORT**

Contract DAAK80-79-C-0789

For the Period July 1981-September 1981

**Object of Study:
To Establish an Automated Production
Process for Ruggedized Tactical
Fiber Optic Cable**

Approved for public release; distribution unlimited.

Prepared for:

**U.S. Army Communications
Research and Development Command
Procurement Directorate, Procurement Division D
Fort Monmouth, New Jersey 07703**

Prepared by:

**ITT Electro-Optical Products Division
7635 Plantation Road, N.W.
Roanoke, Virginia 24019**

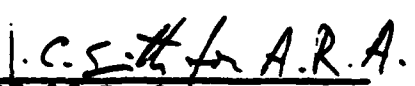
S OCT 27 1982

A

Approved by:


**R. J. Hoss, Program Manager,
Fiber Optics**

Approved by:


**Adolf R. Asan,
Senior Group Manager,
Cable**

**Date: October 30, 1981
Doc Id No: 81-42-05a**

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CORADCOM-79-0789-7A	2. GOVT ACCESSION NO. AD-A120780	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MANUFACTURING METHODS AND TECHNOLOGY PROGRAM FOR RUGGEDIZED TACTICAL FIBER OPTIC CABLE	5. TYPE OF REPORT & PERIOD COVERED Seventh Progress Report July 1981-September 1981	
	6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s) D. Taylor	8. CONTRACT OR GRANT NUMBER(s) DAAK80-79-C-0789	
9. PERFORMING ORGANIZATION NAME AND ADDRESS ITT Electro-Optical Products Division 7635 Plantation Road, N.W. Roanoke, Virginia 24019	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Communications Research and Development Command Procurement Directorate, Procurement Division D ATTN: DRDCO-PC-D, Ft. Monmouth, New Jersey 07703	12. REPORT DATE October 1981	
	13. NUMBER OF PAGES 33	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified	
	16. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Fiber Optic Cable, Fiber Optic Communications, Fiber Optic, Tactical Fiber Optic Cable		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report covers the period from July 1981 through September 1981 of the manufacturing methods and technology program for ruggedized tactical fiber optic cable. The scope of this effort, as reported herein, includes the following tasks and achievements: Obtained CECOM approval for Estane [®] 58309 polyurethane jacketing com- pound,		

DD FORM 1473

EDITION OF 1 NOV 64 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

20. ABSTRACT (continued)

- b. Selected optical fibers for 12 confirmatory samples)
- c. Fabricated 12 confirmatory sample cables, AND
- d. Evaluated optically, mechanically, and environmentally the confirmatory samples according to the test plan,



A

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SUMMARY

This report covers the period from July 1 to September 30, 1981, of the manufacturing methods and technology (MM&T) program for a ruggedized tactical fiber optic cable.

During this time frame CECOM approval was obtained for the use of B.F. Goodrich Estane® 58309 polyurethane as a replacement for Roylar® E-80. Ten cables of the confirmatory sample phase were fabricated and evaluated. During this phase three cables had to be remade due to equipment failures. The confirmatory sample cables passed all optical, environmental, and mechanical tests with the exception of the low temperature impact test.

TABLE OF CONTENTS (continued)

<u>PARAGRAPH</u>	<u>TITLE</u>	<u>PAGE</u>
8.0	PROGRAM FOR NEXT QUARTER	33
APPENDIXES		
A	OPTICAL TEST DATA	A-1
B	FUNGUS TESTING RESULTS	B-1
C	HUMIDITY TEST DATA	C-1
D	VIBRATION TEST DATA	D-1
E	TEMPERATURE SHOCK TEST DATA	E-1
F	FINISHED CABLE TEST DATA	F-1
G	TEMPERATURE CYCLING DATA	G-1
H	DISTRIBUTION LIST	H-1

1.0 POLYURETHANE EVALUATION APPROVAL

An intensive study of a polyurethane jacketing compound was completed. This study was needed because the original compound manufacturer sold the polyurethane business line and the buyer had some difficulties reproducing the original jacketing compound. The study consisted of testing the polyurethane jacket for its effect on the mechanical properties of the cable and its effect on the optical performance of fibers at low temperature (-55°C).

Five short samples of cables with three different lot numbers and three different extrusion temperature profiles were fabricated and evaluated for impact, twist-bend, and flexure resistance at room temperature, at -55°C, and at +71°C. Two long cables were also tested for impact resistance at -55°C. These tests demonstrated that Estane® 58309 BLK-289 meets the mechanical requirements of MM&T-789898.

Three cables were fabricated for optical evaluation (attenuation and dispersion). The attenuation was measured at room temperature and at -55°C. Two of these cables met the -55°C attenuation goal demonstrating that Estane® 58309 BLK-289 does not appreciably affect the optical performance characteristics of fibers at that temperature.

The polyurethane jacket compound study was completed prior to the fabrication and evaluation of 12 confirmatory sample cables to ensure compliance with specification MM&T-789898.

On July 1, 1981, personnel from ITT EOPD visited CECOM and presented the results of the polyurethane evaluation task. CECOM approved the compound selected by ITT EOPD (B.F. Goodrich's Estane® 58309 BLK-289). The following changes to the program were agreed upon

- a. Change from Roylar® E-80 to Estane® 58309 polyurethane
- b. Slip delivery of the confirmatory sample cables from 29 June to 31 August
- c. Slip delivery of the pilot run from 27 October to 18 December

The CECOM representatives accepted these changes with the provision that ITT EOPD provide the following compensation:

- a. Color code fibers (ink is acceptable)
- b. Include an addendum in the confirmatory sample test plan to cover the test setup for the twist-bend test. This was the problem area due to operator interpretation of procedures which led to failures
- c. Add one quarterly report for period ending 31 October 1981

ITT EOPD accepted these compensations and was given a verbal go-ahead.

CECOM representatives were concerned about the surface finish of the cable. As a result, they wanted as dull a finish as possible. Since, however, a dull surface finish was not specified in the contract and since the effect of any modification on the performance characteristics of polyurethane is unknown, ITT EOPD agreed only to explore the possibility of providing a dull finish in the future.

2.0 FIBER SELECTION

Fibers used for the fabrication of 12 confirmatory sample cables were selected based on the following ITT specifications at room temperature before cabling:

a. Fiber core	50 $\mu\text{m} \pm 5 \mu\text{m}$
b. Fiber outside diameter (od)	125 $\mu\text{m} \pm 6 \mu\text{m}$
c. Attenuation at 0.82 μm	<4.5 dB/km
d. Dispersion at 0.82 μm	<1.7 ns/km
e. Numerical aperture (NA) (90% power)	>0.17
f. Proof-test	689.5 MPa
g. Dow Corning Sylgard® 184 buffer	0.3 mm
h. Hytrel® 7246 jacket	0.9 mm
i. Fiber length	1.1 km

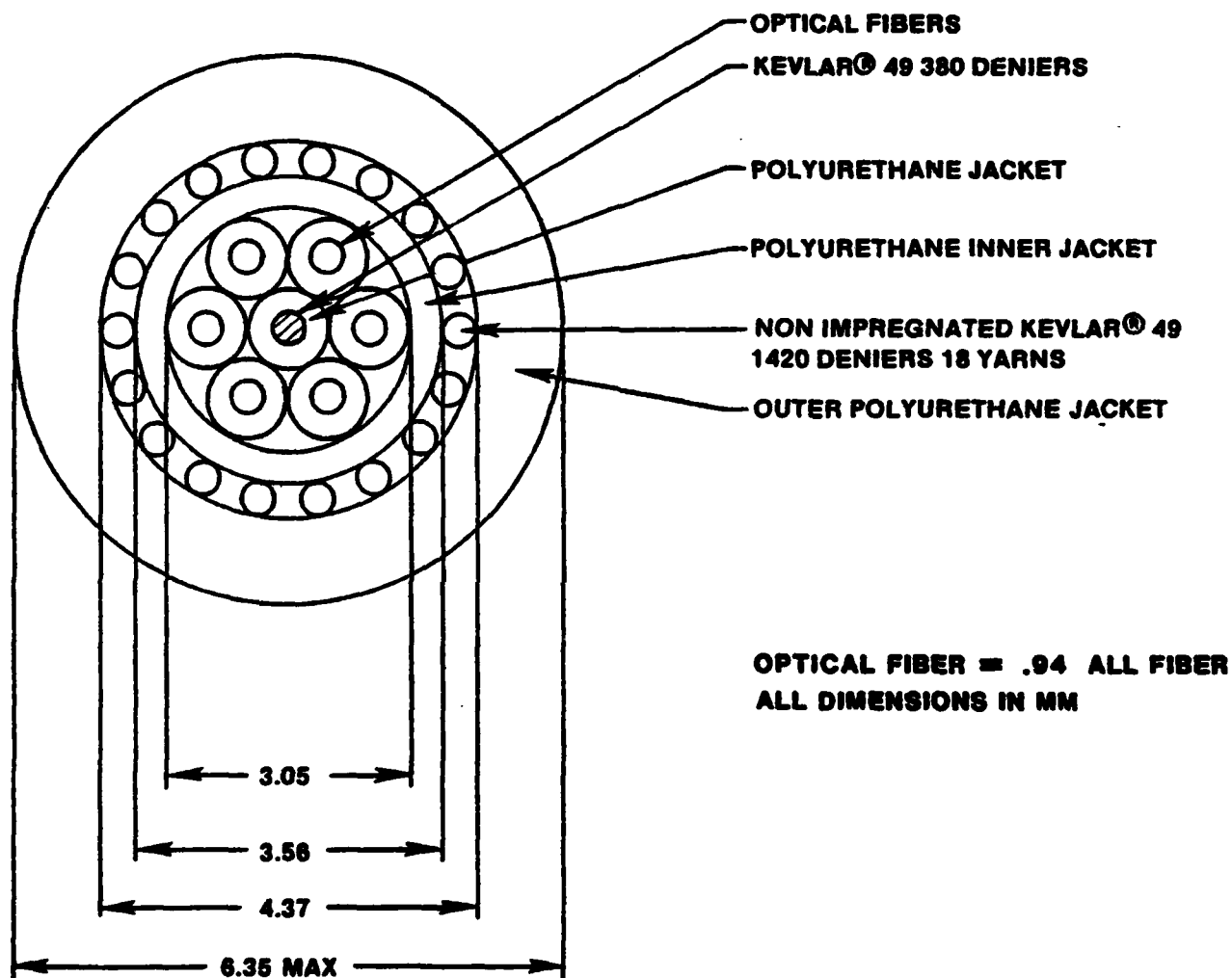
These specifications were chosen to take into account cabling excess loss, dispersion changes during cabling and startup, and end losses experienced during fiber and cable jacketing.

3.0 FABRICATION OF CONFIRMATORY SAMPLE CABLES

Twelve confirmatory cables were fabricated. Figure 3.0-1 shows the cable configuration fabricated. Three cables failed and will have to be replaced.

One cable failed extrusion of the final jacket. Two temperature controllers which control extruder barrel heat zones malfunctioned. This malfunction resulted in a viscosity change of the plastic and, hence, a change in cable jacket diameter fluctuation. The final length of the cable was 989 m. The second cable was rejected for a broken fiber approximately 600 m from the end. The third cable was rejected for jacket damage during high temperature testing. The controller governing the temperature of the test chamber malfunctioned and allowed the temperature to rise above the set point. This malfunction was corrected by installing a controller that can be adjusted to a few degrees above the test temperature and will shut off the unit if the set point temperature is reached.

One of the three replacement cables has been fabricated and tested. The fibers for the remaining two cables are being selected and evaluated.



302 10747

Figure 3.0-1. Basic MM&T Cable Design.

4.0 EVALUATION OF CONFIRMATORY CABLES

The results of optical, environmental, and mechanical tests performed on confirmatory cables are described on the following pages.

4.1 Confirmatory Sample Preproduction Lot

The confirmatory sample preproduction test lot consists of 12 1-km cables wound on DR-5 reels. The mechanical test samples were selected from 3 of the 12 reels. Environmental test samples consisted of 1-km cables wound on DR-5 reels, with the exception of short samples for the fungus tests. Of the remaining nine cables, three were exposed to all environmental tests. Three cables were allocated individually for one of the three environmental tests. A total of four samples were evaluated in each test. The samples were selected and allocated at random. Refer to Figure 4.1-1 for the preproduction test procedure flow chart. Tables 4.1-1 and 4.1-2 outline the test performed on each individual cable.

4.2 Optical Test

4.2.1 Attenuation Test

The attenuation tests were performed by the cutback method. This procedure is described in the test report for phase 3 MM&T cables in Appendix A. The optical attenuation of each cabled fiber was measured at six selected wavelengths: 8,200; 8,500; 10,600;



Table 4.1-1. Confirmatory Sample Cables.

<u>Cable Number</u>	<u>Batch Number</u>
1	071781-4C-1
2	071881-4C-1
3	071881-4C-2
4	071881-4C-3
5	072081-4C-1
6	071681-4C-1
7	072081-4C-2
8	082781-4C-1
10	091881-4C-2
12	091781-4C-1

Table 4.1-2. Cable MM&T Confirmatory Samples.

	Cable Number											
	1	2	3	4	5	6	7	8	9	10	11	12
DR-5 reels	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Length test	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Weight test	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Outer diameter	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fiber dimensions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Atten (various wavelengths and NA)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pulse dispersion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mechanical tests (tensile load)	-	-	✓	-	✓	-	✓	-	-	-	-	-
Finish cable test	-	-	✓	-	✓	-	✓	-	-	-	-	-
Fungus test	-	✓	-	-	✓	-	✓	-	-	-	-	-
High temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Low temperature	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 4.1-2. Cable MM&T Confirmatory Samples (continued).

	Cable Number											
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>
Temperature shock	-	/	-	-	/*	/	/	-	-	-	-	-
Humidity	-	/	-	/*	-	/	/	-	-	-	-	-
Vibration	-	/	-	-	-	/	/	/*	-	-	-	-
Cut to length	/	/	/	/	/	/	/	/	/	/	/	/

*Control cable.

11,000; 12,000; and 13,000 Å. All the cable samples were tested to meet the <5 dB/km attenuation requirement.

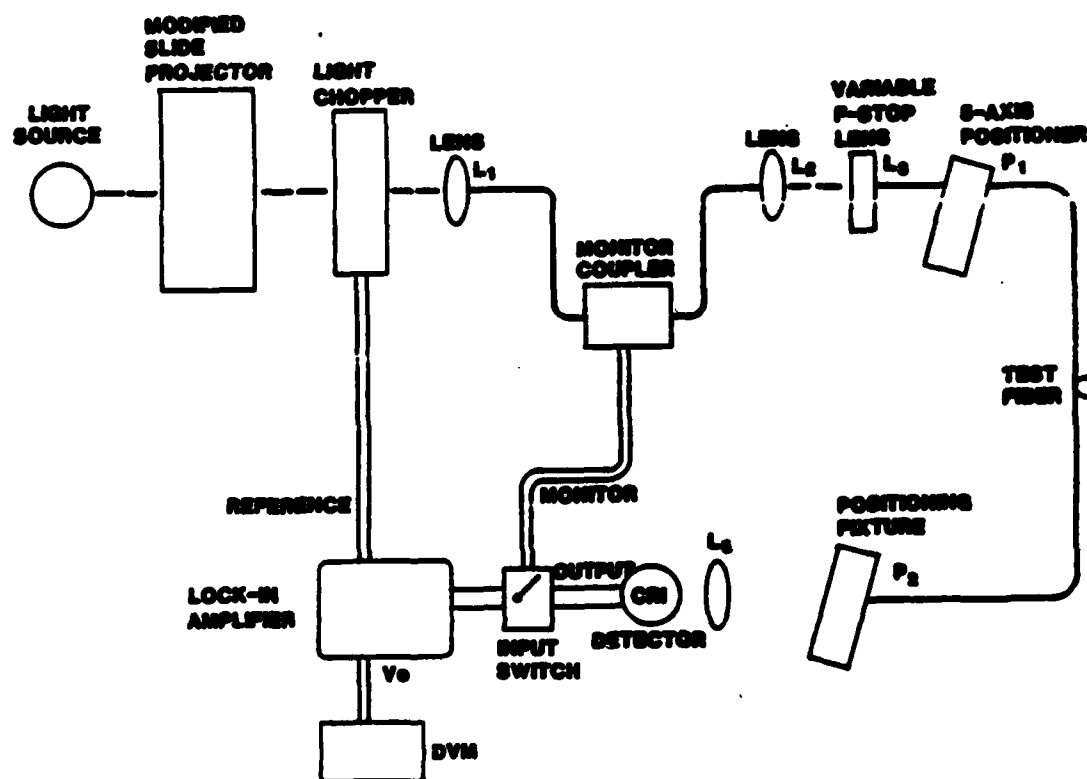
The calculation procedure followed Method 6020 of MIL-STD-1678. The output through the fiber was measured at 0.82 μm for injection numerical apertures of 0.89, 0.124, 0.176, and 0.243. The attenuation at each of the remaining five wavelengths was measured at an injected NA of 0.089. The single injection NA was selected to avoid changing injection NA conditions at each wavelength thereby eliminating input variation between the short and long length measurements.

Once the output through the long length was measured at the specified wavelengths, the fiber was cut at a distance of 1 m from the injection end. A new end was prepared on the output end of the reference length and the measurement repeated for the short length. The attenuation test setup is shown in Figure 4.2.1-1.

The attenuation of each test fiber at all six wavelengths with an input NA of 0.089, except at 0.827 μm where four injection NA values were used, is reported. All fibers tested passed the specification. Results are recorded in Appendix A.

4.2.2 Pulse Dispersion

All confirmatory cables were tested for pulse dispersion to



902 13371

Figure 4.2.1-1. Attenuation Test Setup.

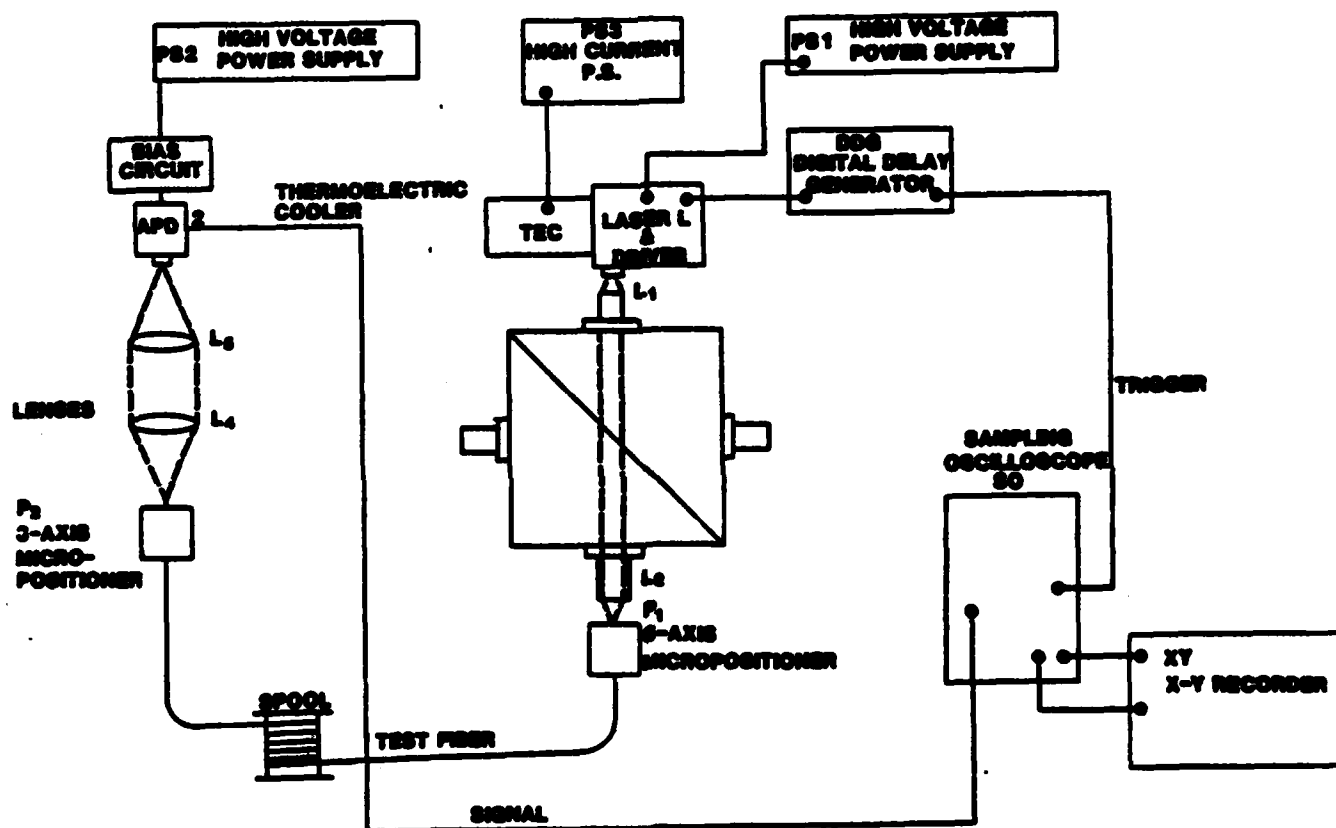
determine if the requirement of 2 ns/km maximum was met. The 50% (3 dB) optical pulse dispersion of the test fiber was measured using existing equipment (Figure 4.2.2-1) operating at 9000 Å. Method 6050 of DOD-STD-1678 was utilized. The 50% pulse dispersion requirements of optical fibers were met. The results of the testing of optical fibers are recorded in Appendix A.

4.2.3 Numerical Aperture (NA)

All confirmatory cables were tested to determine if the NA requirement of >0.17 was met. The exit NA, defined as $\sin \theta/2$ where θ is the core angle containing 90% of the output power of each cabled fiber, was measured at a wavelength of 0.82 μm . The required NA specification was met for each optical fiber and is reported in Appendix A. The NA station is illustrated in Figure 4.2.3-1.

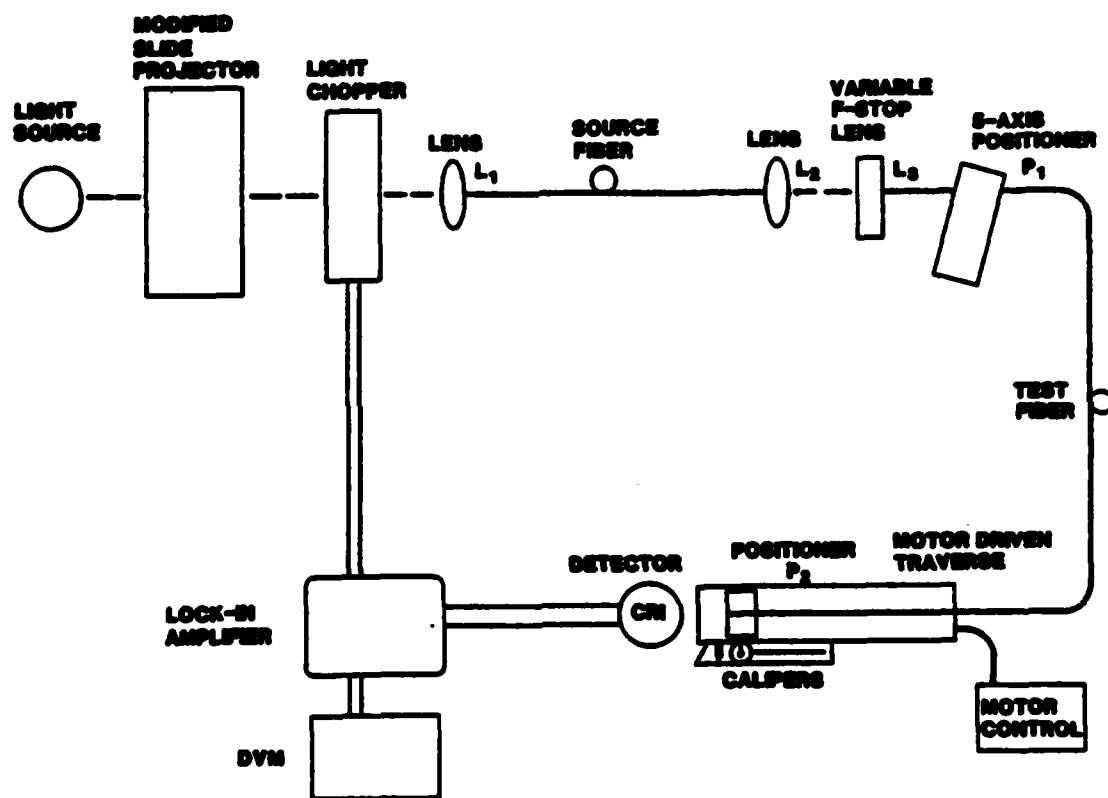
4.3 Environmental Test

Environmental test samples consisted of 1-km cables wound on DR-5 reels, with the exception of short samples for the fungus tests. All 12 reels were subjected to high and low temperature cycling. Six cables were allocated individually for one of the six environmental tests (fungus, humidity, temperature shock, and vibration). A total of seven samples was evaluated in each test. All samples were selected and allocated at random.



302 13365

Figure 4.2.2-1. Pulse Dispersion Test Setup.



382 13372

Figure 4.2.3-1. Test Setup of 90% Power Numerical Aperture (NA).

4.3.1 Fungus Test

Fungus testing was conducted in accordance with MIL-STD-810B, Method 508.1, Procedure I, at the Aerospace Research Corp. in Roanoke, Virginia. The samples contained small unrelated colonies of fungus. A very light surface growth was evident but was easily wiped clean with a dry paper towel (per specification). The fungus test was successfully met and the results are described in Appendix B.

4.3.2 High Temperature Cycle

Each cable sample was tested in accordance with MIL-STD-810, Method 501.1, Procedure II, except that steps 7 and 8 were omitted per program requirements and paragraph 4.1 of the preproduction procedures for ruggedized tactical fiber optic cable, ITT Doc Id No 80-29-09, Revision III. There was no breakage of individual fibers or other visible cable damage and all cables met the optical requirements. The optical results are recorded in Appendix G.

4.3.3 Low Temperature Cycle

The cable samples were tested in accordance with MIL-STD-810, Method 502.1, Procedure I, except that steps 4 and 5 were omitted and paragraph 4.2 of the MM&T preproduction test procedure for ruggedized tactical fiber optic cable, ITT Doc Id No 80-29-09, Revision III. There was no visible cable damage and there were no broken fibers. The low temperature cycle test passed and optical results are reported in Appendix G.

4.3.4 Humidity Cycle

Four cables were subjected to the humidity cycle in accordance with MIL-STD-810, Method 507.1, Procedure II, and paragraph 4.4 of the MM&T preproduction test plan for ruggedized tactical fiber optic cable, ITT Doc Id No 80-29-09, Revision III. The four cable samples were evaluated for attenuation, dispersion, and 90% power NA after humidity test. There was no visible cable damage and no broken fibers and the cables met all optical requirements. The optical results are reported in Appendix C.

4.3.5 Vibration Test

Four 1-km cables were subjected to secured cargo and loose cargo tests during the vibration phase. The vibration tests were conducted in accordance with paragraph 4.6 of the preproduction test procedure for ruggedized tactical fiber optic cable, ITT Doc Id No 80-29-09, Revision III. The attenuation for each cable at the specified wavelengths was measured along with the dispersion and 90% power NA with no significant change. No damage to the cable or reel occurred during the test. The vibration test was successfully met and test results are recorded in Appendix D.

4.3.6 Temperature Shock

Four cable samples were subjected to the temperature shock cycle in accordance with MIL-STD-810, Method 503.1, and paragraph 4.3 of the preproduction test procedures for ruggedized tactical fiber

optic cable, ITT Doc Id No 80-29-09, Revision III. The four cable samples were evaluated for attenuation, dispersion, and 90% power NA after this test with excellent results. All requirements were met and test results are recorded in Appendix E.

4.4 Finished Cable Test

Three cable samples were subjected to static tensile load and mechanical test. The cables were subjected to a static tensile load and impact, twist-bend at room temperature, high temperature (+71°C), and low temperature (-54°C).

4.4.1 Static Tensile Load Test

Three cable samples were subjected to a static tensile load of 1780 N (400 lbf) in accordance with paragraph 3.1 of the preproduction test procedure for ruggedized tactical fiber optic cable, ITT Doc Id No 80-29-09, Revision III. There was no breakage of individual fibers or visible cable damage within the gage length. The static tensile load test passed requirements and test results are recorded in Appendix F.

4.4.2 Mechanical Test

Three 15-m lengths were cut from test cables for the mechanical testing. The cables were subjected to impact, twist, and bend tests at room temperature, high temperature (+71°C), and low temperature (-54°C). Impact testing was performed at a loading of 3 ft·lbf. The load mass for twist and bend was 22 lb_m (10 kg).

The cable samples were tested in accordance with the preproduction test procedure for ruggedized tactical fiber optic cable, ITT Doc Id No 80-29-09, Revision III.

4.4.2.1 Impact Test

Three 15-m lengths of test cable were subjected to impact test at room temperature, +71°C, and -54°C. These cables were tested in accordance with paragraph 3.2.1 of the preproduction test procedure for ruggedized tactical fiber optic cable, ITT Doc Id No 80-29-09, Revision III, and DOD-STD-1678, Method 2030, Procedure I. Impact testing was performed at a loading of 3 ft·lb_f. The cable samples passed all the tests except low temperature impact. This failure is being investigated in detail. All test cables successfully passed the twist test. The results of the impact testing are recorded in Appendix F.

4.4.2.2 Twist Test

Three 15-m lengths of test cable were subjected to twist test at room temperature, +71°C, and -54°C. These cables were tested in accordance with paragraph 3.2.2 the preproduction test procedure for ruggedized tactical fiber optic cable, ITT Doc Id No 80-29-09, Revision III, and DOD-STD-1678, Method 2060, Procedure I. The load mass for the twist test was 22 lb_m (10 kg). There was no visible cable damage and there were no broken fibers. All test cables successfully passed the twist test. The results of the twist test are recorded in Appendix F.

4.4.2.3 Bend Test

Three 15-m lengths of test cable were subjected to bend test at room temperature, +71°C, and -54°C. These cables were tested in accordance with paragraph 3.2.3 of the preproduction test procedure for ruggedized tactical fiber optic cable, ITT Doc Id No 80-29-09, Revision III, and DOD-STD-1678, Method 2010, Procedure I. The load mass for the bend test was 22 lb_m (10 kg). There was no visible cable damage and there were no broken fibers. All cable samples passed the test. The results of the bend test are recorded in Appendix F.

5.0 CABLE MANUFACTURING PROCESS, EQUIPMENT, TOOLING, AND MEASUREMENTS

This section describes the manufacturing process, equipment and tooling used to manufacture the MM&T cable as well as optical evaluation of the cables.

5.1 Cable Manufacturing Process

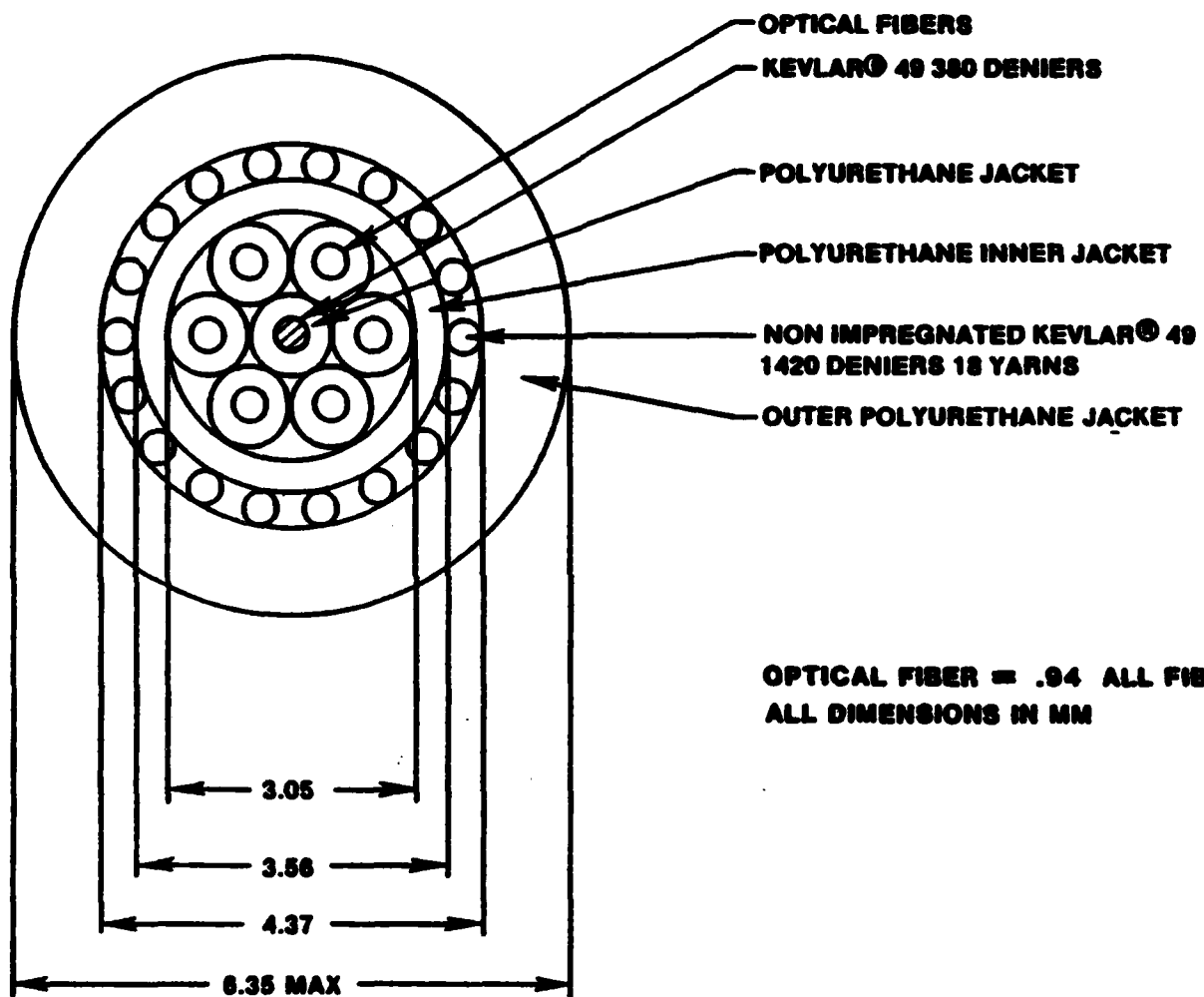
The basic MM&T cable design is shown in Figure 5.1-1. The cable fabrication flow chart is shown in Figure 5.1-2.

The MM&T cable optical core contains six optical fibers contrahelically laid around a polyurethane coated Kevlar® central member. A jacket of polyurethane is extruded over the optical core. Then the jacketed optical core is served with 18 Kevlar® strength members before a final jacket of polyurethane is applied.

5.1.1 Fiber Rewind Station

This station (Figure 5.1-2, Operation E1) is used to respool and inspect fibers in preparation for the subsequent stranding operation. The equipment consists of a rewinder, an optical lump detector to examine the fiber buffer jacket for any nonuniformities, and a constant-tension compensating payoff to eliminate fiber breaks.

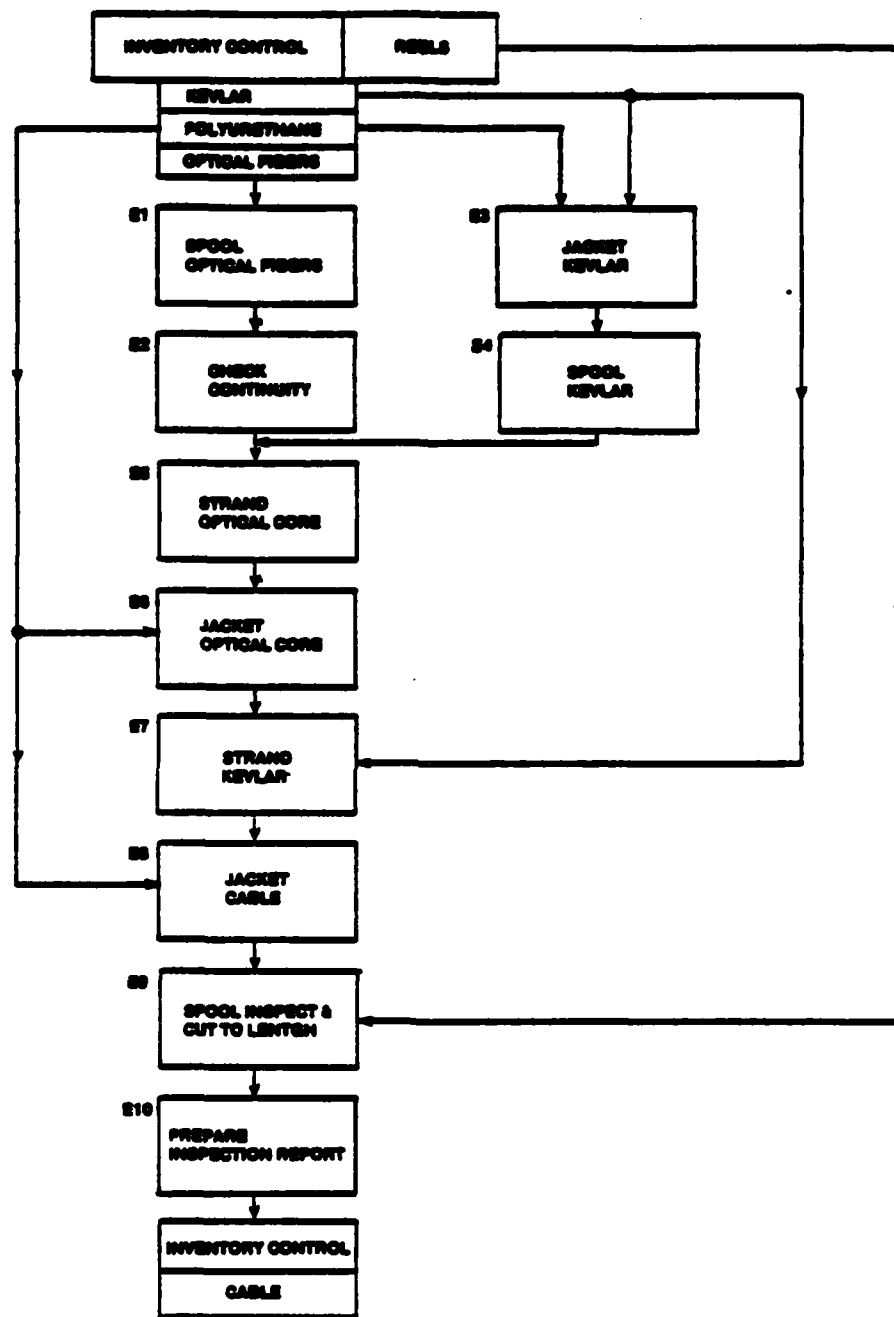
This unit is also used to visually inspect fibers for buffer jacket flaws.



**OPTICAL FIBER = .94 ALL FIBER
ALL DIMENSIONS IN MM**

302 10757

Figure 5.1-1. Basic MM&T Cable Design.



102 15670

Figure 5.1-2. Cable Fabrication Flow Chart.

5.1.2 Fiber Continuity Check Station

Before fibers are stranded into a cable bundle, continuity of each fiber is tested and any defects or broken fibers are removed. The unit used at this station (Figure 5.1-2, Operation E2) is an instrument designed for detecting and locating faults in optical fibers, for measuring their length, and for analyzing their transmission characteristics. The instrument operates by launching a pulse of laser light into the fiber and monitoring the amplitude and time delay of events in the light reflected back along the fiber.

5.1.3 Kevlar® Jacketing Station

This station (Figure 5.1-2, Operation E3) is used to overcoat a Kevlar® 49-380 denier yarn with a polyurethane jacket which is used as the central core for the optical bundle. A 1-in extruder is used to pressure extrude the polyurethane jacket at a rate of 76 m/min. An automatic diameter control unit is used, which measures the extruded jacket diameter of the core element and regulates the line speed to provide a constant diameter over the existing cable length.

5.1.4 Respooling Station for Polyurethane Jacketed Kevlar® Central Strength Member

The identical equipment as used for the fiber rewind operation (paragraph 5.1.1) is employed. The capacity of this unit is ample to perform both fiber rewind and central strength member respooling operations.

5.1.5 Optical Core Stranding Station

This station is used (Figure 5.1-2, Operation E5) to strand six optical fibers helically around the polyurethane Kevlar® jacketed central strength member. A high speed single twist closing unit equipped with a 13-bay neutralizing unit is employed. The unit operates at 1800 m/h.

5.1.6 Optical Core Jacketing Station

Station E6, Figure 5.1-2, is used to extrude the polyurethane jacket over the optical core. The jacket is applied with a 1-1/2-in extrusion line capable of extruding the first jacket at 68 m/min.

5.1.7 Kevlar® Stranding Station

Station E7, Figure 5.1-2, is employed to strand 18 Kevlar® strength members around the jacketed optical core. The Kevlar® stranding machine contrahelically serves the 18 Kevlar® strength members around the optical core. The Kevlar® serving line is capable of stranding Kevlar® at 20 m/min.

5.1.8 Final Jacketing Station

A 2-in extrusion line (Figure 5.1-2, Operation E8) is used to extrude the final cable jacket. The extrusion line is capable of extruding the final jacket at 42 m/min which is double the rate required for the MM&T program.

5.1.9 Final Cable Respooling Station

The cable is respooled on the Federal cable rewinder (Figure 5.1-2, Operation E9) for shipping. This machine enables an inspector to visually inspect the cable for anomalies and irregularities while being spooled on the DR-5 reels.

6.0 SUMMARY OF ACCOMPLISHMENTS

The objectives of the work performed during this quarter were to

- (a) obtain approval from CECOM for the use of B.F. Goodrich Estane® 58309 as a replacement polyurethane for Roylar® E-80 and
- (b) fabricate and evaluate confirmatory sample cables.

The approval for use of the Estane® 58309 was given during a meeting with ITT EOPD and CECOM representatives on July 1, 1981, at Fort Monmouth, New Jersey. The approval was given on the provision that ITT EOPD would provide the following compensation:

- a. Color code MM&T fibers
- b. Include a change page in the confirmatory sample test plan to cover the test setup for the twist-bend test
- c. Add monthly reports until program completion
- d. Add one quarterly report for the period ending 31 October 1981

Twelve confirmatory cables were fabricated. Three cables failed and will be replaced. One cable failed during extrusion of the final jacket. Two temperature controllers that determine the temperature of the extruder barrel malfunctioned. This malfunction changed the viscosity of the plastic, causing bridging in the extruder. Bridging causes an uneven plastic flow which results in cable diameter fluctuation. The final length of this cable was 989 m. The second cable was disqualified for a broken fiber approximately 600 m from the end. The third cable was being high

temperature tested when the voltage regulator for the electronic circuit changed values. The result was an increase in the temperature of the test chamber, causing damage to the cable jacket.

All optical, environmental, and mechanical tests performed on confirmatory cable samples were successfully completed with the exception of the low temperature impact test. Cable samples tested at 3 ft-lb and -55°C resulted in one or more broken fibers. This failure is being investigated in detail.

7.0 PERSONNEL

The personnel involved in the cable MM&T program, their responsibilities, and their hours expended on the program during this period are listed in Table 7.0-1.

Table 7.0-1. Personnel Working on the MM&T Program.

<u>Name</u>	<u>Responsibility</u>	<u>Man-Hours Expended</u>
R. Coon	Program management	66
J. Smith	Senior project engineer	44
D. Taylor	Cable production	143

Table 7.0-2. Man-Hours Expended Compared With Plan.

<u>Proposed</u>	<u>Program Manager</u>	<u>Engineer</u>	<u>Manufacturing</u>	<u>Support</u>	<u>Total</u>
Program to date	540	7,144	4,120	1,000	12,804
<u>Actual</u>					
This period	76	102	1,627	-	1,805
Program to date	727	5,393	4,854	273	11,247

8.0 PROGRAM FOR NEXT QUARTER

The program for the next quarter includes the following objectives:

- a. Complete fabrication and evaluation of confirmatory cables.
- b. Investigate low temperature impact failure.
- c. Select optical fibers for pilot run.
- d. Submit monthly progress reports.

APPENDIX A
OPTICAL TEST DATA

Table A-1. Dimensional Measurements.

Cable 1: 071781-4C-1

Fiber Identification	Core Diameter (μm)		Cladding Diameter (μm)	
	SOP*	EOP**	SOP*	EOP**
1 Blue	51 x 50	45 x 48	126	126
2 Orange	51 x 50	45 x 48	126	126
3 Brown	49	49	128	126 x 124
4 White	51 x 50	49 x 48	124	123 x 122
5 Slate	53	53 x 52	126	124
6 Green	53 x 52	51 x 54	125	126

Cable 2: 071881-4C-1

1 Blue	51 x 50	51 x 50	124 x 123	124 x 122
2 Orange	51	52 x 51	125 x 124	123 x 122
3 Brown	53 x 52	53	126	126
4 White	53	53 x 52	126	124
5 Slate	49 x 47	51 x 50	126	127 x 126
6 Green	49	50	126	128 x 126

* Start of pull, bottom spool.

** End of pull, top of spool.

Table A-1. Dimensional Measurements (continued).

Cable 3: 071881-4C-2

Fiber Identification	Core Diameter (μm)		Cladding Diameter (μm)	
	<u>SOP*</u>	<u>EOP**</u>	<u>SOP*</u>	<u>EOP**</u>
1 Blue	50 x 48	47 x 45	126 x 125	126
2 Orange	50 x 49	50 x 49	125 x 124	125 x 124
3 Brown	47 x 45	48	126	126
4 White	50	49 x 46	124 x 123	125 x 124
5 Slate	51 x 49	51 x 49	126 x 124	125 x 124
6 Green	51 x 50	51 x 50	124 x 123	124 x 122

Cable 4: 071881-4C-3

1 Blue	49 x 48	49 x 48	127 x 124	126
2 Orange	50 x 47	50 x 47	126 x 125	126 x 124
3 Brown	53	51 x 50	126 x 124	126 x 124
4 White	49 x 46	52 x 51	127 x 126	127 x 125
5 Slate	53 x 52	51 x 54	125	126
6 Green	50 x 49	49 x 48	126 x 125	126 x 125

* Start of pull, bottom spool.

** End of pull, top of spool.

Table A-1. Dimensional Measurements (continued).

Cable 5: 072081-4C-1

Fiber Identification	Core Diameter (μm)		Cladding Diameter (μm)	
	<u>SOP*</u>	<u>EOP**</u>	<u>SOP*</u>	<u>EOP**</u>
1 Blue	49 x 48	50 x 48	124 x 123	126 x 124
2 Orange	52 x 53	51 x 52	123 x 124	124 x 125
3 Brown	48	50 x 48	126 x 125	126
4 White	52 x 51	52 x 50	126 x 124	126 x 124
5 Slate	49 x 48	50 x 49	125 x 126	126
6 Green	52 x 50	50 x 49	127	127 x 126

Cable 6: 071681-4C-1

1 Blue	50 x 47	49 x 46	126 x 124	126 x 124
2 Orange	49 x 46	46	125 x 124	125 x 124
3 Brown	50 x 49	50 x 49	125 x 124	124 x 123
4 White	51 x 50	53	126 x 124	126 x 125
5 Slate	49 x 47	49 x 48	123 x 122	124
6 Green	51 x 50	51 x 50	128	128 x 127

* Start of pull, bottom spool.

** End of pull, top of spool.

Table A-1. Dimensional Measurements (continued).

Cable 7: 072081-4C-2

Fiber Identification	Core Diameter (μm)		Cladding Diameter (μm)	
	SOP*	EOP**	SOP*	EOP**
1 Blue	53 x 52	53 x 51	128 x 127	127 x 126
2 Orange	48	50 x 48	126 x 125	126
3 Brown	54 x 51	54 x 51	129	127 x 126
4 White	48 x 47	49 x 49	127 x 126	125 x 123
5 Slate	50 x 49	50 x 48	126 x 125	124 x 123
6 Green	49	50 x 49	126	125

Cable 8: 082781-4C-1

1 Blue	48 x 46	48 x 47	126 x 125	127 x 126
2 Orange	52 x 50	54 x 53	126	126 x 125
3 Brown	53 x 51	50 x 48	126	127 x 126
4 White	52 x 51	51	126 x 124	126 x 123
5 Slate	51 x 50	50 x 49	127 x 127	127 x 126
6 Green	52 x 51	51 x 50	126 x 125	126

* Start of pull, bottom spool.

** End of pull, top of spool.

Table A-1. Dimensional Measurements (continued).

Cable 10: 091881-4C-2					
1 Blue	50 x 49	52 x 51	128 x 127	126	
2 Orange	50 x 49	49 x 48	124	123 x 122	
3 Brown	52 x 51	52 x 51	126	126	
4 White	52 x 51	51 x 51	126	126	
5 Slate	48 x 50	50 x 51	123 x 124,	125 x 127	
6 Green	55 x 52	51 x 50	126 x 124	127 x 125	

* Start of pull, bottom spool.

** End of pull, top of spool.

Table A-1. Dimensional Measurements (continued).

Cable 12: 091781-4C-1					
1 Blue	49 x 50	50 x 51	124 x 126	124 x 125	
2 Orange	51 x 50	49 x 48	125 x 124	124 x 123	
3 Brown	51 x 49	48	125 x 123	126 x 124	
4 White	49	50 x 49	123	124 x 122	
5 Slate	52 x 54	52	126	125	
6 Green	53 x 52	51 x 51	123 x 123	124 x 123	

A-7

* Start of pull, bottom spool.

** End of pull, top of spool.

Table A-2. Cable Results, Cable 1 and Cable 2.

		<u>Cable 1: 071781-4C-1</u>		
<u>Fiber id</u>	<u>Attenuation (dB/km)</u>		<u>Dispersion (ns/km)</u>	
	<u>Before</u>	<u>After</u>	<u>Before</u>	<u>Δ</u>
1 Blue	3.65	3.09	0.36	0.37 +0.01
2 Orange	3.65	3.25	0.36	0.51 +0.15
3 Brown	3.14	3.07	0.93	1.09 +0.16
4 White	2.94	2.55	0.52	1.52 +1.00
5 Slate	3.43	3.15	0.76	1.35 +0.59
6 Green	<u>3.42</u>	<u>3.30</u>	<u>0.33</u>	<u>0.52</u> +0.19
Average	3.37	3.06	0.54	0.89 +0.35
		<u>Cable 2: 071881-4C-1</u>		
<u>Fiber id</u>	<u>Attenuation (dB/km)</u>		<u>Dispersion (ns/km)</u>	
	<u>Before</u>	<u>After</u>	<u>Before</u>	<u>Δ</u>
1 Blue	3.47	4.22	1.03	0.94 -0.09
2 Orange	3.52	3.68	0.72	0.77 +0.05
3 Brown	2.94	3.04	0.52	0.72 +0.20
4 White	2.94	3.32	0.52	0.84 +0.32
5 Slate	3.12	3.87	1.34	1.39 +0.05
6 Green	<u>3.31</u>	<u>2.84</u>	<u>0.97</u>	<u>0.48</u> -0.49
Average	3.21	3.49	0.85	0.87 +0.02

Table A-3. Cable Results, Cable 3 and Cable 4.

Cable 3: 071881-4C-2					
Fiber id	Attenuation (dB/km)			Dispersion (ns/km)	
	Before	After	Δ	Before	After Δ
1 Blue	3.29	3.23	-0.06	0.44	0.55 +0.11
2 Orange	3.15	3.40	+0.25	0.31	0.52 +0.21
3 Brown	3.34	3.15	-0.19	0.68	0.55 -0.13
4 White	3.20	3.56	+0.36	0.60	0.50 -0.10
5 Slate	3.23	4.11	+0.88	0.34	0.67 +0.33
6 Green	<u>3.47</u>	<u>3.93</u>	<u>+0.46</u>	<u>1.03</u>	<u>1.20</u> <u>+0.17</u>
Average	3.28	3.56	+0.28	0.56	0.66 +0.10
Cable 4: 071881-4C-3					
1 Blue	3.46	3.52	+0.06	0.88	1.09 +0.21
2 Orange	3.65	3.74	+0.09	0.27	0.35 +0.08
3 Brown	3.08	3.13	+0.05	0.75	0.62 -0.13
4 White	3.40	3.40	0.00	0.55	1.22 +0.67
5 Slate	3.42	3.44	+0.02	0.33	0.56 +0.23
6 Green	<u>3.07</u>	<u>3.31</u>	<u>+0.24</u>	<u>0.64</u>	<u>0.56</u> <u>-0.08</u>
Average	3.35	3.42	+0.07	0.57	0.73 +0.16

Table A-4. Cable Results, Cable 5 and Cable 6.

Cable 5: 072081-4C-1

<u>Fiber id</u>	<u>Attenuation (dB/km)</u>			<u>Dispersion (ns/km)</u>		
	<u>Before</u>	<u>After</u>	<u>Δ</u>	<u>Before</u>	<u>After</u>	<u>Δ</u>
1 Blue	4.67	4.53	-0.14	0.92	0.76	-0.16
2 Orange	3.19	3.50	+0.31	1.05	1.37	+0.32
3 Brown	3.34	3.38	+0.04	0.82	1.46	+0.64
4 White	3.23	3.66	+0.43	0.48	0.98	+0.50
5 Slate	3.65	3.63	-0.02	1.09	1.61	+0.52
6 Green	<u>3.21</u>	<u>3.43</u>	<u>+0.22</u>	<u>0.83</u>	<u>0.68</u>	<u>-0.15</u>
Average	3.55	3.69	+0.14	0.87	1.14	+0.27

Cable 6: 071681-4C-1

1 Blue	3.30	3.21	-0.09	0.32	0.32	0.00
2 Orange	3.14	3.14	0.00	0.72	0.72	0.00
3 Brown	3.15	3.08	-0.07	0.31	0.51	+0.20
4 White	3.08	2.82	-0.18	0.75	0.21	-0.54
5 Slate	3.20	2.94	-0.26	0.64	0.69	+0.05
6 Green	<u>3.82</u>	<u>4.07</u>	<u>+0.25</u>	<u>0.63</u>	<u>0.65</u>	<u>+0.02</u>
Average	3.28	3.21	-0.07	0.56	0.52	-0.04

Table A-5. Cable Results, Cable 7 and Cable 8.

Cable 7: 072081-4C-2

Fiber id	<u>Attenuation (dB/km)</u>		<u>Dispersion (ns/km)</u>	
	<u>Before</u>	<u>After</u>	<u>Before</u>	<u>Δ</u>
1 Blue	3.30	3.42	0.77	+0.12
2 Orange	3.25	3.40	0.82	+0.15
3 Brown	3.85	4.18	0.25	+0.33
4 White	3.11	3.34	0.89	+0.23
5 Slate	3.91	4.11	0.39	+0.20
6 Green	<u>4.00</u>	<u>3.73</u>	<u>0.47</u>	<u>-0.27</u>
Average	3.57	3.69	0.60	+0.12

Cable 8: 082781-4C-1

Fiber id	<u>Attenuation (dB/km)</u>		<u>Dispersion (ns/km)</u>	
	<u>Before</u>	<u>After</u>	<u>Before</u>	<u>Δ</u>
1 Blue	3.48	3.31	1.03	-0.17
2 Orange	2.87	2.95	0.81	+0.08
3 Brown	3.13	3.29	0.95	+0.16
4 White	2.62	3.62	0.98	+1.00
5 Slate	3.99	3.94	0.70	-0.05
6 Green	<u>3.89</u>	<u>3.87</u>	<u>0.64</u>	<u>-0.02</u>
Average	3.33	3.50	0.85	+0.17

Table A-6. Cable Results, Cable 10 and Cable 12.

Fiber id	Cable 10: 09181-4C-2			Cable 12: 091781-4C-1		
	Attenuation (dB/km)			Dispersion (ns/km)		
	Before	After	Δ	Before	After	Δ
1 Blue	3.39	3.64	+0.25	1.17	1.05	-0.12
2 Orange	3.68	3.34	-0.34	1.39	1.00	-0.39
3 Brown	2.52	4.30	+1.78	1.55	0.43	-1.12
4 White	3.48	2.96	-0.52	1.37	1.04	-0.33
5 Slate	3.39	4.01	+0.61	1.57	0.52	-1.05
6 Green	<u>4.26</u>	<u>3.67</u>	<u>-0.59</u>	<u>1.29</u>	<u>1.49</u>	<u>+0.20</u>
Average	3.45	3.65	+0.20	1.39	0.92	-0.47

Table A-7. Attenuation Versus Wavelength After Cabling (dB/km).*

Cable 1: 071781-4C-1

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	3.63	3.09	1.3	1.2	1.05	1.87
2 Orange	3.74	3.25	1.65	1.25	1.12	1.51
3 Brown	3.60	3.07	1.41	1.24	1.09	1.30
4 White	4.05	2.55	1.68	1.61	1.42	1.66
5 Slate	3.53	3.15	1.38	1.32	1.12	1.54
6 Green	4.82	3.30	3.17	2.43	2.13	1.58

Cable 2: 071881-4C-1

1 Blue	4.75	4.22	2.33	2.05	1.73	2.17
2 Orange	4.24	3.68	2.05	1.90	1.60	1.37
3 Brown	3.41	3.04	1.53	1.33	1.11	1.46
4 White	3.81	3.32	1.57	1.47	1.13	2.10
5 Slate	4.15	3.87	2.02	1.82	1.67	1.23
6 Green	3.39	2.84	1.09	0.96	0.8	1.28

*Injected NA 0.089.

Table A-7. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Cable 3: 071881-4C-2

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	3.86	3.23	1.50	1.34	1.14	1.42
2 Orange	3.94	3.40	1.68	1.50	1.59	3.03
3 Brown	3.55	3.15	1.78	1.32	1.21	0.75
4 White	4.02	3.56	1.59	1.50	1.24	1.23
5 Slate	4.46	4.11	2.39	2.03	1.77	0.66
6 Green	4.27	3.93	1.87	1.47	1.11	1.41

Cable 4: 071881-4C-3

1 Blue	4.08	3.52	1.56	1.51	1.19	1.19
2 Orange	4.19	3.74	1.85	1.72	1.50	1.36
3 Brown	3.69	3.13	1.20	1.11	0.90	1.01
4 White	3.95	3.40	1.65	1.53	1.30	1.25
5 Slate	3.94	3.44	1.73	1.65	1.37	1.24
6 Green	3.83	3.31	1.60	1.45	1.22	0.89

*Injected NA 0.089.

Table A-7. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Cable 5: 072081-4C-1

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	5.02	4.53	2.67	2.58	2.36	2.65
2 Orange	3.73	3.50	1.14	0.93	0.68	0.42
3 Brown	3.91	3.38	1.58	1.43	1.25	1.15
4 White	4.12	3.66	1.73	1.61	1.17	1.26
5 Slate	4.31	3.63	1.39	1.14	0.78	0.57
6 Green	3.92	3.46	1.59	5.0	1.21	1.10

Cable 6: 071681-4C-1

1 Blue	3.71	3.21	1.42	1.26	1.05	1.32
2 Orange	3.85	3.45	1.72	1.62	1.32	1.54
3 Brown	3.49	3.08	1.36	1.22	1.22	3.46
4 White	3.28	2.82	1.27	1.13	0.91	1.42
5 Slate	3.34	2.94	1.30	1.35	1.16	1.97
6 Green	4.63	4.02	1.86	1.80	1.01	1.82

*Injected NA 0.089.

Table A-7. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Cable 7: 072081-4C-2

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	3.99	3.42	1.57	1.42	1.11	2.62
2 Orange	4.11	3.40	1.62	1.45	1.25	0.77
3 Brown	4.77	4.18	2.17	2.05	1.71	1.37
4 White	4.03	3.34	1.55	1.38	1.16	1.36
5 Slate	4.56	4.11	1.95	1.82	1.50	1.37
6 Green	4.32	3.73	2.03	1.93	1.65	1.28

Cable 8: 082781-4C-1

1 Blue	3.79	3.31	1.55	1.45	1.42	3.19
2 Orange	3.39	2.95	1.25	1.12	0.84	0.90
3 Brown	3.84	3.29	1.43	1.31	1.03	1.04
4 White	4.15	3.62	1.92	1.78	1.44	1.32
5 Slate	4.46	3.94	1.88	1.66	1.41	1.51
6 Green	4.43	3.87	2.16	2.00	1.72	1.63

*Injected NA 0.089.

Table A-7. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Cable 10: 001881-4C-2

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	4.27	3.64	2.12	2.01	2.06	2.51
2 Orange	3.87	3.34	1.73	1.61	1.34	1.27
3 Brown	4.81	4.30	2.42	2.25	2.05	2.05
4 White	3.40	2.96	1.21	1.30	1.14	1.31
5 Slate	4.37	4.01	2.64	2.48	2.27	2.28
6 Green	4.20	3.67	1.79	1.58	1.30	1.05

Cable 12: 091781-4C-1A

1 Blue	4.62	4.19	2.34	2.19	1.86	1.99
2 Orange	3.47	3.03	1.58	1.46	1.27	1.26
3 Brown	3.45	3.00	1.50	1.39	1.20	1.30
4 White	3.92	3.37	1.70	1.55	1.29	1.37
5 Slate	4.09	3.70	2.16	2.05	1.87	1.99
6 Green	3.28	3.03	1.42	1.26	1.05	0.97

*Injected NA 0.089.

Table A-8. Attenuation Versus Wavelength After Cabling (dB/km).*

Cable 1: 071781-4C-1

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	3.63	3.09	1.3	1.2	1.05	1.87
2 Orange	3.74	3.25	1.65	1.25	1.12	1.51
3 Brown	3.60	3.07	1.41	1.24	1.09	1.30
4 White	4.05	2.55	1.68	1.61	1.42	1.66
5 Slate	3.53	3.15	1.38	1.32	1.12	1.54
6 Green	4.82	3.30	3.17	2.43	2.13	1.58

Cable 2: 071881-4C-1

1 Blue	4.75	4.22	2.33	2.05	1.73	2.17
2 Orange	4.24	3.68	2.05	1.90	1.60	1.37
3 Brown	3.41	3.04	1.53	1.33	1.11	1.46
4 White	3.81	3.32	1.57	1.47	1.13	2.10
5 Slate	4.15	3.87	2.02	1.82	1.67	1.23
6 Green	3.39	2.84	1.09	0.96	0.8	1.28

*Injected NA 0.089.

Table A-8. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Cable 3: 071881-4C-2

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	3.86	3.23	1.50	1.34	1.14	1.42
2 Orange	3.94	3.40	1.68	1.50	1.59	3.03
3 Brown	3.55	3.15	1.78	1.32	1.21	0.75
4 White	4.02	3.56	1.59	1.50	1.24	1.23
5 Slate	4.46	4.11	2.39	2.03	1.77	0.66
6 Green	4.27	3.93	1.87	1.47	1.11	1.41

Cable 4: 071881-4C-3

1 Blue	4.08	3.52	1.56	1.51	1.19	1.19
2 Orange	4.19	3.74	1.85	1.72	1.50	1.36
3 Brown	3.69	3.13	1.20	1.11	0.90	1.01
4 White	3.95	3.40	1.65	1.53	1.30	1.25
5 Slate	3.94	3.44	1.73	1.65	1.37	1.24
6 Green	3.83	3.31	1.60	1.45	1.22	0.89

*Injected NA 0.089.

Table A-8. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Cable 5: 072081-4C-1

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	5.02	4.53	2.67	2.58	2.36	2.65
2 Orange	3.73	3.50	1.14	0.93	0.68	0.42
3 Brown	3.91	3.38	1.58	1.43	1.25	1.15
4 White	4.12	3.66	1.73	1.61	1.17	1.26
5 Slate	4.31	3.63	1.39	1.14	0.78	0.57
6 Green	3.92	3.46	1.59	5.0	1.21	1.10

Cable 6: 071681-4C-1

1 Blue	3.71	3.21	1.42	1.26	1.05	1.32
2 Orange	3.85	3.45	1.72	1.62	1.32	1.54
3 Brown	3.49	3.08	1.36	1.22	1.22	3.46
4 White	3.28	2.82	1.27	1.13	0.91	1.42
5 Slate	3.34	2.94	1.30	1.35	1.16	1.97
6 Green	4.63	4.02	1.86	1.80	1.01	1.82

*Injected NA 0.089.

Table A-8. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Cable 7: 072081-4C-2

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	3.99	3.42	1.57	1.42	1.11	2.62
2 Orange	4.11	3.40	1.62	1.45	1.25	0.77
3 Brown	4.77	4.18	2.17	2.05	1.71	1.37
4 White	4.03	3.34	1.55	1.38	1.16	1.36
5 Slate	4.56	4.11	1.95	1.82	1.50	1.37
6 Green	4.32	3.73	2.03	1.93	1.65	1.28

Cable 8: 082781-4C-1

1 Blue	3.79	3.31	1.55	1.45	1.42	3.19
2 Orange	3.39	2.95	1.25	1.12	0.84	0.90
3 Brown	3.84	3.29	1.43	1.31	1.03	1.04
4 White	4.15	3.62	1.92	1.78	1.44	1.32
5 Slate	4.46	3.94	1.88	1.66	1.41	1.51
6 Green	4.43	3.87	2.16	2.00	1.72	1.63

*Injected NA 0.089.

Table A-8. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Cable 10: 001881-4C-2									
1	Blue	4.27	3.64	2.12	2.01	2.06	2.51		
2	Orange	3.87	3.34	1.73	1.61	1.34	1.27		
3	Brown	4.81	4.30	2.42	2.25	2.05	2.05		
4	White	3.40	2.96	1.21	1.30	1.14	1.31		
5	Slate	4.37	4.01	2.64	2.48	2.27	2.28		
6	Green	4.20	3.67	1.79	1.58	1.30	1.05		

*Injected NA 0.089.

Table A-8. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

<u>Cable 12: 091781-4C-1A</u>						
1	Blue	4.62	4.19	2.34	2.19	1.86
2	Orange	3.47	3.03	1.58	1.46	1.27
3	Brown	3.45	3.00	1.50	1.39	1.20
4	White	3.92	3.37	1.70	1.55	1.29
5	Slate	4.09	3.70	2.16	2.05	1.87
6	Green	3.28	3.03	1.42	1.26	1.05
						0.97

*Injected NA 0.089.

APPENDIX B
FUNGUS TESTING RESULTS

AEROSPACE RESEARCH CORPORATION
TEST DATA

CUSTOMER ITT Electro-Optical Division TEST ITEM Fiber Optic Cable
TEST SPECIFICATION MIL-STD-810B, Method 508.1, Procedure I
PARAGRAPH NUMBER _____ PART NUMBER _____
SERIAL NUMBER 2, 5, 7 and TAOC
TEST TITLE Fungus Test
P.O. NUMBER 34395 TEST CONDUCTED BY Gary W. Long
DATE 8-11-81 TEST TEMP. +84 °F ROOM TEMP. +72 °F BAROMETRIC PRESSURE 29.04 In. Hg.

Prior to start of Fungus Test the Optic Fiber samples were cleaned with isopropyl alcohol. The samples were then placed in the Fungus Chamber and sprayed with previously prepared and tested fungus culture. The fungus culture preparation and test were conducted in accordance with MIL-STD-810B, Method 508.1, Procedure 1.

The chamber was maintained at +84°F and 95 percent relative humidity for a period of 28 days. The test was started on August 11, 1981, and was completed on September 8, 1981.

At the end of the 28 day test the samples were visually inspected for fungus growth.

A light fungus growth was observed on all samples.

The Optic Fiber samples were returned to ITT, Electro-Optical Products Division for a complete inspection and test evaluation.

CERTIFICATION

We certify that this test data is a true report on our Fungus Test on four Optic Fiber samples, S/N's 2, 5, 7 and TAOC, submitted by ITT, Electro-Optical Products Division of Roanoke, Virginia. Calibration of our instrumentation is traceable to the National Bureau of Standards.

Respectfully submitted,

AEROSPACE RESEARCH CORPORATION

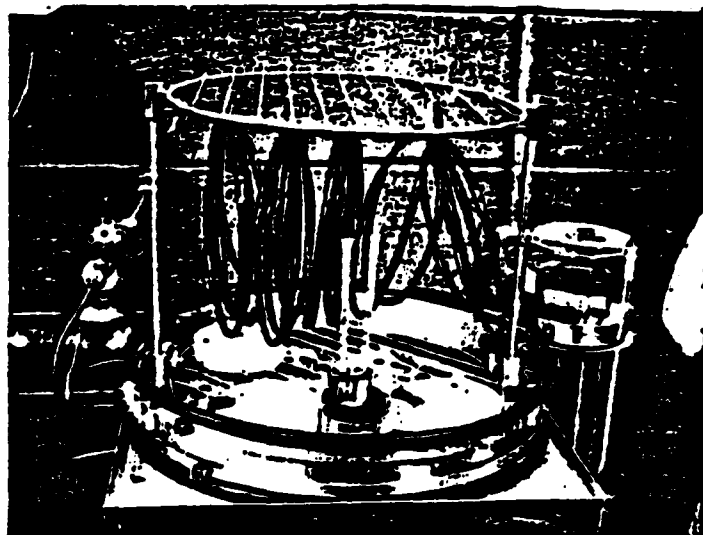
Leslie C. Rose

Leslie C. Rose
Vice President

Subscribed and sworn to before me this 9th day of September, 1981.

Betty C. Fitzpatrick
Notary Public

My commission expires July 16, 1984.



APPENDIX C
HUMIDITY TEST DATA

Table C-1. Humidity Test Cable Results, Cable 2 and Cable 4.

Cable 2: 071881-4C-1

Fiber id	Attenuation (dB/km)		Dispersion (ns/km)	
	Before	After	Before	After
1 Blue	3.98	3.70	1.61	0.96
2 Orange	3.58	3.30	0.75	0.77
3 Brown	3.30	3.33	0.62	0.69
4 White	3.09	3.16	0.74	0.94
5 Slate	3.33	2.12	0.89	1.24
6 Green	3.54	3.08	0.52	0.50
Average	3.47	3.11	0.85	0.85

Cable 4: 071881-4C-3

Fiber id	Attenuation (dB/km)		Dispersion (ns/km)	
	Before	After	Before	After
1 Blue	3.63	3.06	1.28	1.24
2 Orange	3.73	3.79	0.40	0.34
3 Brown	3.24	3.34	0.73	0.68
4 White	3.36	3.37	1.32	1.37
5 Slate	3.42	3.36	0.54	0.56
6 Green	3.45	3.92	0.56	0.64
Average	3.47	3.47	0.80	0.80

Table C-2. Humidity Test Cable Results, Cable 6 and Cable 7.

Cable 6: 071681-4C-1

Fiber id	<u>Attenuation (dB/km)</u>		<u>Dispersion (ns/km)</u>	
	<u>Before</u>	<u>After</u>	<u>Before</u>	<u>After</u>
1 Blue	3.50	3.35	0.69	0.80
2 Orange	3.30	3.49	0.63	0.71
3 Brown	3.57	3.57	0.49	0.56
4 White	3.21	3.52	0.59	0.65
5 Slate	3.21	3.39	0.69	0.75
6 Green	<u>3.87</u>	<u>3.98</u>	<u>0.55</u>	<u>0.78</u>
Average	3.44	3.55	0.61	0.71

Cable 7: 072081-4C-2

1 Blue	3.46	3.22	0.97	0.87	-0.10
2 Orange	3.49	3.43	1.48	1.02	-0.46
3 Brown	4.20	3.50	0.43	0.34	-0.09
4 White	3.67	3.31	1.21	1.09	-0.12
5 Slate	4.40	4.33	0.64	0.58	-0.06
6 Green	<u>3.57</u>	<u>4.21</u>	<u>0.61</u>	<u>0.49</u>	<u>-0.12</u>
Average	3.80	3.67	0.89	0.73	-0.16

Table C-3. Attenuation Versus Wavelength* (dB/km) After Humidity.

Cable 2: 071881-4C-1

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	4.16	3.70	1.71	1.51	1.17	1.05
2 Orange	3.80	3.30	1.51	1.36	1.16	1.33
3 Brown	3.77	3.33	1.73	1.61	1.38	1.42
4 White	3.75	3.16	1.52	1.47	1.20	1.20
5 Slate	3.75	2.12	1.42	1.18	1.10	1.19
6 Green	3.49	3.08	1.46	1.30	1.11	1.13

Cable 4: 071881-4C-3

1 Blue	3.49	3.06	1.37	1.35	1.20	1.36
2 Orange	4.31	3.79	1.92	1.77	1.53	1.56
3 Brown	3.81	3.34	1.57	1.34	1.07	1.06
4 White	3.87	3.37	1.70	1.59	1.47	1.50
5 Slate	3.76	3.36	1.66	1.56	1.29	1.30
6 Green	4.46	3.92	2.20	2.04	1.80	1.81

*Injected NA 0.089.

Table C-3. Attenuation Versus Wavelength* (dB/km) After Humidity (continued).

Cable 6: 071681-4C-1

Fiber Identification	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	3.88	3.35	1.49	1.34	1.16	1.20
2 Orange	3.96	3.49	1.78	1.61	1.37	1.32
3 Brown	3.96	3.57	1.71	1.62	1.69	3.58
4 White	4.02	3.52	1.73	1.58	1.30	1.35
5 Slate	3.89	3.39	1.59	1.46	1.20	1.27
6 Green	4.66	3.98	1.87	1.65	1.37	1.22

Cable 7: 072081-4C-2

1 Blue	3.72	3.22	1.55	1.38	1.14	1.12
2 Orange	3.93	3.43	1.62	1.46	0.62	0.59
3 Brown	3.96	3.50	1.66	1.63	1.52	1.75
4 White	3.90	3.31	1.41	1.47	1.15	1.55
5 Slate	4.88	4.33	2.20	1.99	1.72	1.71
6 Green	4.74	4.21	2.41	2.26	2.09	2.02

*Injected NA 0.089.

Table C-4. Attenuation Versus Injected NA After Humidity Test (Wavelength 820 nm).

Cable 2: 071881-4C-1

Fiber Identification	Injection NA			
	<u>0.089</u>	<u>0.0124</u>	<u>0.0176</u>	<u>0.243</u>
1 Blue	4.16	3.84	2.70	3.36
2 Orange	3.80	2.79	3.73	3.82
3 Brown	3.77	3.77	3.44	3.40
4 White	3.75	3.52	2.61	3.03
5 Slate	3.75	3.56	3.60	2.49
6 Green	3.49	3.32	2.61	2.42

Cable 4: 071881-4C-3

1 Blue	3.49	3.51	3.57	3.57
2 Orange	4.31	4.36	4.23	4.30
3 Brown	3.81	3.99	4.06	4.08
4 White	3.87	3.65	3.25	3.27
5 Slate	3.76	3.75	4.04	4.13
6 Green	4.46	4.43	4.49	4.81

Table C-4. Attenuation Versus Injected NA After Humidity Test (Wavelength 820 nm) (continued).

Fiber Identification	Cable 6: 071681-4C-1		
	Injection NA		
	0.089	0.0124	0.0176
1 Blue	3.88	3.98	3.85
2 Orange	3.96	3.97	4.08
3 Brown	3.96	3.74	4.10
4 White	4.02	4.01	4.30
5 Slate	3.89	3.90	4.00
6 Green	4.66	4.70	4.61
			0.243
			4.01
			4.26
			4.15
			4.29
			4.06
			4.83

Cable 7: 072081-4C-2		
1 Blue	3.72	3.92
2 Orange	3.93	3.86
3 Brown	3.96	3.84
4 White	3.90	4.04
5 Slate	4.88	4.80
6 Green	4.74	4.92
		4.00
		3.98
		3.43
		3.93
		4.86
		5.02
		4.23
		4.24
		4.09
		3.91
		4.87
		5.03

Table C-5. Numerical Aperture (90% Power) After Temperature Cycling Test.

<u>Fiber</u> <u>Identification</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>
1 Blue	0.19	0.22	0.18	0.22	0.20	0.21	0.22	0.20	-	0.19	-	0.20
2 Orange	0.19	0.21	0.19	0.20	0.19	0.23	0.20	0.21	-	0.20	-	0.19
3 Brown	0.18	0.22	0.21	0.21	0.23	0.20	0.22	0.20	-	0.18	-	0.18
4 White	0.21	0.25	0.19	0.20	0.19	0.22	0.22	0.22	-	0.21	-	0.19
5 Slate	0.20	0.27	0.20	0.23	0.20	0.21	0.23	0.20	-	0.18	-	0.20
6 Green	0.19	0.23	0.19	0.21	0.19	0.21	0.21	0.22	-	0.20	-	0.19

APPENDIX D
VIBRATION TEST DATA

14205a

D-1

Table D-1. Vibration Test Cable Results, Cable 2 and Cable 6.

Cable 2: 071881-4C-1

<u>Fiber id</u>	<u>Attenuation (dB/km)</u>			<u>Dispersion (ns/km)</u>		
	<u>Before</u>	<u>After</u>	<u>Δ</u>	<u>Before</u>	<u>After</u>	<u>Δ</u>
1 Blue	3.70	3.56	-0.14	0.96	1.61	+0.65
2 Orange	3.30	3.59	+0.29	0.77	0.75	-0.02
3 Brown	3.33	3.52	+0.19	0.69	0.62	-0.07
4 White	3.16	2.95	-0.21	0.94	0.74	-0.20
5 Slate	2.12	2.92	+0.80	1.24	0.89	-0.35
6 Green	<u>3.08</u>	<u>3.17</u>	<u>+0.09</u>	<u>0.50</u>	<u>0.52</u>	<u>+0.02</u>
Average	3.11	3.28	+0.17	0.85	0.85	0.00

Cable 6: 071681-4C-1

<u>Fiber id</u>	<u>Attenuation (dB/km)</u>			<u>Dispersion (ns/km)</u>		
	<u>Before</u>	<u>After</u>	<u>Δ</u>	<u>Before</u>	<u>After</u>	<u>Δ</u>
1 Blue	3.35	2.27	-1.08	0.80	0.80	0.00
2 Orange	3.49	3.78	+0.29	0.71	0.82	+0.11
3 Brown	3.57	3.40	-0.17	0.56	0.50	-0.06
4 White	3.52	2.26	-1.26	0.65	0.62	-0.03
5 Slate	3.39	3.12	-0.26	0.75	0.66	-0.09
6 Green	<u>3.98</u>	<u>3.56</u>	<u>-0.42</u>	<u>0.78</u>	<u>0.62</u>	<u>-0.16</u>
Average	3.55	3.07	-0.48	0.71	0.67	-0.04

Table D-2. Vibration Test Cable Results, Cable 7 and Cable 8.

Cable 7: 072081-4C-2

Fiber id	Attenuation (dB/km)		Dispersion (ns/km)		
	Before	After	Δ	Before	After
1 Blue	3.22	3.50	+0.28	0.87	0.89
2 Orange	3.43	2.92	-0.51	1.02	1.22
3 Brown	3.50	4.46	+0.96	0.34	0.36
4 White	3.31	3.03	-0.28	1.09	1.05
5 Slate	4.33	4.12	-0.21	0.58	0.59
6 Green	4.21	3.84	-0.37	0.49	0.54
Average	3.67	3.64	-0.03	0.73	0.77

Cable 8: 082781-4C-1

1 Blue	4.07	3.36	-0.71	1.80	1.58
2 Orange	2.81	2.97	+0.16	0.75	0.75
3 Brown	3.06	3.20	+0.14	0.48	0.50
4 White	3.46	3.44	-0.02	1.22	1.28
5 Slate	3.32	4.42	+1.10	0.86	0.88
6 Green	3.62	4.24	+0.62	0.74	0.75
Average	3.40	3.61	+0.21	0.97	0.95

Table D-3. Attenuation Versus Wavelength* (dB/km) After Vibration.

Cable 2

Fiber Identification	Wavelength (nm)				
	820	850	1060	1100	1300
1 Blue	4.14	3.56	1.58	1.40	1.01
2 Orange	3.98	3.59	1.77	1.63	1.41
3 Brown	3.52	3.08	1.50	1.34	1.18
4 White	3.40	2.95	1.43	1.24	1.08
5 Slate	3.42	2.92	1.10	1.14	1.31
6 Green	3.49	3.17	1.44	1.37	1.09

Cable 6: 071681-4C-1

1 Blue	3.40	2.27	1.13	1.33	1.26	1.69
2 Orange	3.89	3.78	1.94	1.64	1.39	1.35
3 Brown	3.83	3.40	1.69	1.58	1.62	2.48
4 White	2.96	2.26	1.26	1.00	0.73	0.80
5 Slate	3.63	3.12	1.53	1.39	1.18	1.23
6 Green	4.12	3.56	1.63	1.48	1.21	1.16

*Injected NA 0.089.

Table D-3. Attenuation Versus Wavelength* (dB/km) After Vibration (continued).

Cable 7: 072081-4C-2

Fiber Identification	Wavelength (nm)					
	<u>620</u>	<u>850</u>	<u>1060</u>	<u>1100</u>	<u>1200</u>	<u>1300</u>
1 Blue	4.04	3.50	1.71	1.50	1.21	1.23
2 Orange	3.07	2.92	1.63	1.67	1.69	1.87
3 Brown	4.93	4.46	2.46	2.27	1.97	1.97
4 White	3.50	3.03	1.32	1.23	1.02	1.33
5 Slate	4.59	4.12	2.07	1.88	1.49	1.59
6 Green	4.37	3.84	2.17	2.05	1.75	1.74

Cable 8: 082781-4C-1

1 Blue	3.92	3.36	1.62	1.45	1.44	3.17
2 Orange	3.37	2.97	1.33	1.22	0.99	1.07
3 Brown	3.57	3.20	1.45	1.28	1.07	1.22
4 White	3.89	3.44	1.69	1.62	1.29	1.24
5 Slate	4.50	4.42	2.04	1.78	1.38	1.27
6 Green	4.74	4.24	2.48	2.38	2.17	2.07

*Injected NA 0.089.

Table D-4. Attenuation Versus Injected NA After Vibration (Wavelength 820 nm).

Cable 2: 071881-4C-1

Fiber Identification	Injection NA		
	<u>0.089</u>	<u>0.0124</u>	<u>0.0176</u>
1 Blue	4.14	4.16	4.22
2 Orange	3.98	4.01	4.19
3 Brown	3.52	3.67	3.69
4 White	3.40	3.36	3.67
5 Slate	3.42	3.50	3.63
6 Green	3.61	3.48	3.58
			<u>0.243</u>
			4.36
			4.44
			3.65
			3.76
			3.80
			3.71

Cable 6: 071681-4C-1

1 Blue	3.40	3.40	3.54	3.65
2 Orange	3.89	3.96	3.86	4.10
3 Brown	3.83	3.89	4.01	4.07
4 White	2.96	2.42	2.26	2.27
5 Slate	3.63	3.63	3.64	3.93
6 Green	4.12	3.97	4.01	4.18

Table D-4. Attenuation Versus Injected NA After Vibration (Wavelength 820 nm)
(continued).

Cable 7: 072081-4C-2

Fiber Identification	Injection NA		
	<u>0.089</u>	<u>0.0124</u>	<u>0.0176</u>
1 Blue	4.04	4.14	4.46
2 Orange	3.07	4.70	4.08
3 Brown	4.93	4.95	4.88
4 White	3.50	3.34	3.58
5 Slate	4.59	4.28	4.31
6 Green	4.37	4.55	4.61
			<u>0.243</u>
			4.48
			3.82
			5.27
			3.78
			4.45
			4.72

Cable 8: 082781-4C-1

1 Blue	3.92	3.69	3.90	3.89
2 Orange	3.37	3.54	3.64	3.63
3 Brown	3.57	3.61	3.85	3.91
4 White	3.89	3.88	3.85	3.39
5 Slate	4.50	4.57	3.91	3.77
6 Green	4.74	4.67	4.97	5.04

Table D-5. Numerical Aperture (90% Power) After Vibration.

<u>Fiber</u> <u>Identification</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>
1 Blue	-	0.18	-	-	-	0.19	0.18	0.19	-	-	-	-
2 Orange	-	0.19	-	-	-	0.19	0.18	0.18	-	-	-	-
3 Brown	-	0.19	-	-	-	0.19	0.20	0.19	-	-	-	-
4 White	-	0.19	-	-	-	0.19	0.20	0.19	-	-	-	-
5 Slate	-	0.19	-	-	-	0.20	0.19	0.18	-	-	-	-
6 Green	-	0.18	-	-	-	0.19	0.19	0.23	-	-	-	-

44

AEROSPACE RESEARCH CORPORATION
TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)
TEST SPECIFICATION Doc. Id. No. 80-29-09, Revision II
PARAGRAPH NUMBER 4.6 PART NUMBER _____
SERIAL NUMBER # 2
TEST TITLE Vibration Test (Loose Cargo)
P.O. NUMBER 34394-01 TEST CONDUCTED BY Gary W. Long
DATE 9-26-81 TEST TEMP. +70 °F ROOM TEMP. +70 °F BAROMETRIC PRESSURE 29.20 In. Hg.

The Loose Cargo Vibration Test was conducted in accordance with paragraph 4.6 of Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was placed in the test fixture with reel axis perpendicular to test bed of package tester. The package tester operated at 284 r.p.m., with 1 inch vertical double displacement. The sample was vibrated for 30 minutes.

The reel was then turned 180 degrees and tested for 30 minutes.

The reel was then placed in the axis parallel to the test bed and tested for 30 minutes. After 30 minutes vibration the reel was turned 180 degrees and vibrated for 30 minutes.

At the conclusion of the 2 hour vibration test the sample was inspected for evidence of visible physical damage and none was observed.

Remarks: The reel of Fiber Optic Cable was returned to ITT for complete inspection and test evaluation.

45

AEROSPACE RESEARCH CORPORATION
TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)
TEST SPECIFICATION Doc. Id No. 80-29-09, Revision II
PARAGRAPH NUMBER 4.6 PART NUMBER _____
SERIAL NUMBER # 2
TEST TITLE Vibration Test (Secured Cargo)
P.O. NUMBER 34395-01 TEST CONDUCTED BY S.D. Bernard
DATE 9-25-81 TEST TEMP. +78 °F ROOM TEMP. +78 °F BAROMETRIC PRESSURE 29.33 In. Hg.

The Secured Cargo Vibration Test was conducted in accordance with Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was mounted on the vibration exciter and subjected to the following secured cargo vibration test in the lateral and longitudinal axes. The vibration time was 84 minutes per axis. The sweep time from 6 to 200 to 6 Hz was 12 minutes.

<u>Frequency, Hz</u>	<u>G level</u>
6 - 200	1.5

At the conclusion of the vibration test the sample was inspected for evidence of visible physical damage and none was observed.

4

CERTIFICATION

We certify that this test data is a true report of our Vibration Tests (Secured Cargo, and Loose Cargo) on one reel of Fiber Optic Cable, submitted by ITT, Electro-Optical Products Division, Roanoke, Virginia. Calibration of our instrumentation is traceable to the National Bureau of Standards.

Respectfully submitted,

AEROSPACE RESEARCH CORPORATION

Leslie C. Rose

Leslie C. Rose
Vice President

Subscribed and sworn to before me this 29th day of September, 1981.

Betty C. Fitzpatrick
Notary Public

My commission expires July 16, 1984.

41

AEROSPACE RESEARCH CORPORATION
TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)
TEST SPECIFICATION Doc. Id No. 80-29-09, Revision II
PARAGRAPH NUMBER 4.6 PART NUMBER _____
SERIAL NUMBER #6 and #7
TEST TITLE Vibration Test (Secured Cargo)
P.O. NUMBER 34395-01 TEST CONDUCTED BY Henry Messenger
DATE 9-21-81 TEST TEMP. -70 °F ROOM TEMP. -70 °F BAROMETRIC PRESSURE 29.05 In. Hg.

The Secured Cargo Vibration Test was conducted in accordance with Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was mounted on the vibration exciter and subjected to the following secured cargo vibration test in the lateral and longitudinal axes. The vibration time was 84 minutes per axis. The sweep time from 6 to 200 to 6 Hz was 12 minutes.

<u>Frequency, Hz</u>	<u>G level</u>
6 - 200	1.5

At the conclusion of the vibration test the sample was inspected for evidence of visible physical damage and none was observed.

48

AEROSPACE RESEARCH CORPORATION
TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)
TEST SPECIFICATION Doc. Id. No. 80-29-09, Revision II
PARAGRAPH NUMBER 4.6 PART NUMBER _____
SERIAL NUMBER #6 and #7
TEST TITLE Vibration Test (Loose Cargo)
P.O. NUMBER 34395-01 TEST CONDUCTED BY Gary W. Long
DATE 9-22-81 TEST TEMP. +70 °F ROOM TEMP. +70 °F BAROMETRIC PRESSURE 29.00 In. Hg.

The Loose Cargo Vibration Test was conducted in accordance with paragraph 4.6 of Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was placed in the test fixture with reel axis perpendicular to test bed of package tester. The package tester operated at 284 r.p.m., with 1 inch vertical double displacement. The sample was vibrated for 30 minutes.

The reel was then turned 180 degrees and tested for 30 minutes.

The reel was then placed in the axis parallel to the test bed and tested for 30 minutes. After 30 minutes vibration the reel was turned 180 degrees and vibrated for 30 minutes.

At the conclusion of the 2 hour vibration test the sample was inspected for evidence of visible physical damage and none was observed.

Remarks: The reel of Fiber Optic Cable was returned to ITT for complete inspection and test evaluation.

46

CERTIFICATION

We certify that this test data is a true report of our Vibration Tests (Secured Cargo and Loose Cargo) on two reels of Fiber Optic Cable. S/N's 6 and 7, submitted by ITT, Electro-Optical Products Division, Roanoke, Va. Calibration of our instrumentation is traceable to the National Bureau of Standards.


Respectfully submitted,

AEROSPACE RESEARCH CORPORATION



Leslie C. Rose
Vice President

Subscribed and sworn to before me this 22nd day of September, 1981.


Notary Public

My commission expires July 16, 1984.

5

AEROSPACE RESEARCH CORPORATION
TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)
TEST SPECIFICATION Doc. Id. No. 80-29-09, Revision 11
PARAGRAPH NUMBER 4.6 PART NUMBER _____
SERIAL NUMBER #8
TEST TITLE Vibration Test (Loose Cargo)
P.O. NUMBER 34395 TEST CONDUCTED BY Gary W. Long
DATE 9-17-81 TEST TEMP. +75 °F ROOM TEMP. +75 °F BAROMETRIC PRESSURE 29.03 In. Hg.

The Loose Cargo Vibration Test was conducted in accordance with paragraph 4.6 of Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision 11.

The test sample was placed in the test fixture with reel axis perpendicular to test bed of package tester. The package tester operated at 284 r.p.m., with 1 inch vertical double displacement. The sample was vibrated for 30 minutes.

The reel was then turned 180 degrees and tested for 30 minutes.

The reel was then placed in the axis parallel to the test bed and tested for 30 minutes. After 30 minutes vibration the reel was turned 180 degrees and vibrated for 30 minutes.

At the conclusion of the 2 hour vibration test the sample was inspected for evidence of visible physical damage and none was observed.

Remarks: The reel of Fiber-Optic Cable was returned to ITT for complete inspection and test evaluation.

5

AEROSPACE RESEARCH CORPORATION
TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)
TEST SPECIFICATION Doc. Id No. 80-29-09, Revision II
PARAGRAPH NUMBER 4.6 PART NUMBER _____
SERIAL NUMBER #8
TEST TITLE Vibration Test (Secured Cargo)
P.O. NUMBER 34395 TEST CONDUCTED BY S.D. Bernard
DATE 9-16-81 TEST TEMP. +79 °F ROOM TEMP. -79 °F BAROMETRIC PRESSURE 28.93 In. Hg.

The Secured Cargo Vibration Test was conducted in accordance with Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was mounted on the vibration exciter and subjected to the following secured cargo vibration test in the lateral and longitudinal axes. The vibration time was 84 minutes per axis. The sweep time from 6 to 200 to 6 Hz was 12 minutes.

<u>Frequency, Hz</u>	<u>G level</u>
6-200	1.5

At the conclusion of the vibration test the sample was inspected for evidence of visible physical damage and none was observed.

CERTIFICATION

We certify that this test data is a true report on our Vibration Tests (Secured Cargo, and Loose Cargo) on one reel Fiber Optic Cable, submitted by ITT, Electro-Optical Products Division, Roanoke, Virginia. Calibration of our instrumentation is traceable to the National Bureau of Standards.

Respectfully submitted,

AEROSPACE RESEARCH CORPORATION



Leslie C. Rose
Vice President

Subscribed and sworn to before me this 18th day of September, 1981.


Notary Public

My commission expires July 16, 1984.

APPENDIX E
TEMPERATURE SHOCK TEST DATA

Table E-1. Temperature Shock Test Cable Results, Cable 2 and Cable 5.

Cable 2: 071881-4C-1

<u>Fiber id</u>	<u>Attenuation (dB/km)</u>		<u>Dispersion (ns/km)</u>		
	<u>Before</u>	<u>After</u>	<u>Δ</u>	<u>Before</u>	<u>After</u>
1 Blue	3.61	3.98	+0.37	1.08	1.05
2 Orange	3.46	3.58	+0.12	0.80	0.96
3 Brown	3.09	3.30	+0.21	0.78	0.75
4 White	2.95	3.09	+0.14	1.01	1.07
5 Slate	3.14	3.33	+0.19	1.20	1.29
6 Green	<u>3.29</u>	<u>3.54</u>	<u>+0.25</u>	<u>0.63</u>	<u>0.54</u>
Average	3.26	3.47	+0.21	0.91	0.94
					+0.03

Cable 5: 072081-4C-1

1 Blue	4.27	3.31	-0.96	0.11	0.96	+0.85
2 Orange	3.50	3.37	-0.13	1.21	1.29	+0.08
3 Brown	2.26	3.32	+1.06	1.52	1.12	-0.40
4 White	3.38	3.37	-0.01	0.92	0.91	-0.01
5 Slate	3.62	3.45	-0.17	1.24	1.35	+0.11
6 Green	<u>3.39</u>	<u>4.21</u>	<u>+0.82</u>	<u>0.52</u>	<u>0.64</u>	<u>+0.12</u>
Average	3.40	3.50	+0.10	0.92	1.04	+0.12

Table E-2. Temperature Shock Test Cable Results, Cable 6 and Cable 7.

Cable 6: 071681-4C-1						
Fiber id	Attenuation (dB/km)			Dispersion (ns/km)		
	Before	After	Δ	Before	After	Δ
1 Blue	3.30	3.50	+0.20	0.76	0.69	-0.06
2 Orange	3.50	3.30	-0.20	0.73	0.63	-0.10
3 Brown	3.45	3.57	+0.12	0.52	0.49	-0.03
4 White	4.14	3.21	-0.93	0.66	0.59	-0.07
5 Slate	3.08	3.21	+0.13	0.71	0.69	-0.02
6 Green	3.90	3.87	-0.03	0.74	0.55	-0.19
Average	3.56	3.44	-0.12	0.69	0.61	-0.08

Cable 7: 072081-4C-2						
Fiber id	Attenuation (dB/km)			Dispersion (ns/km)		
	Before	After	Δ	Before	After	Δ
1 Blue	3.90	3.46	-0.44	0.97	0.97	0.00
2 Orange	3.84	3.49	-0.25	1.26	1.48	+0.22
3 Brown	4.32	4.20	-0.12	0.44	0.43	-0.01
4 White	3.42	3.67	+0.25	1.22	1.21	-0.01
5 Slate	4.40	4.40	0.00	1.02	0.64	-0.38
6 Green	4.32	3.57	-0.75	0.65	0.61	-0.04
Average	4.03	3.81	-0.22	0.93	0.89	-0.04

Table E-3. Attenuation Versus Wavelength* (dB/km) After Temperature Shock Test.

Cable 2: 071881-4C-1

Fiber	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	4.56	3.98	1.95	1.77	1.50	1.43
2 Orange	4.01	3.58	1.76	1.64	1.38	1.49
3 Brown	3.83	3.30	1.70	1.59	1.39	1.38
4 White	3.56	3.09	1.43	1.37	1.17	1.20
5 Slate	3.58	3.33	1.56	1.40	1.13	1.36
6 Green	3.93	3.54	1.8	1.63	1.35	1.36

Cable 5: 072081-4C-1

1 Blue	3.73	3.31	1.51	1.37	1.09	1.20
2 Orange	3.84	3.37	1.65	1.62	1.40	1.47
3 Brown	3.75	3.32	1.74	1.60	1.48	1.42
4 White	3.81	3.37	1.53	1.38	1.12	1.03
5 Slate	4.03	3.45	1.52	1.32	1.07	1.03
6 Green	4.66	4.21	2.68	2.59	2.50	2.60

AD-A120 780

MANUFACTURING METHODS AND TECHNOLOGY PROGRAM FOR
RUGGEDIZED TACTICAL FIBER (U) ITT ELECTRO-OPTICAL
PRODUCTS DIV ROANOKE VA D TAYLOR OCT 81 ITT-81-42-85A
CORADCOM-79-0789-7A DAAK80-79-C-0789 F/G 13/8

2/2

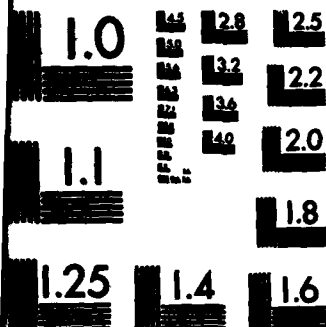
UNCLASSIFIED

NL

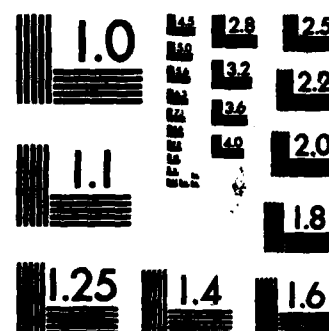
END

FILED

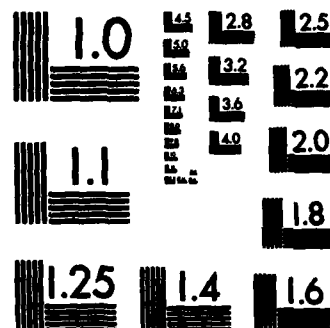
DTIC



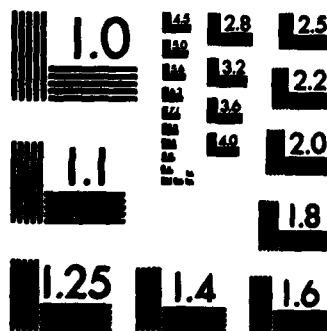
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



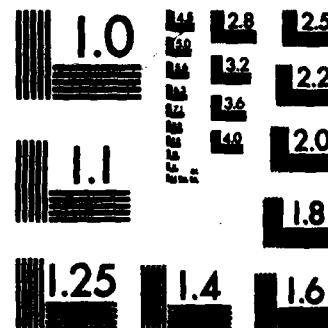
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Table E-3. Attenuation Versus Wavelength* (dB/km) After Temperature Shock Test (continued).

Cable 6: 071681-4C-1

Fiber	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	4.05	3.50	1.65	1.52	1.28	1.42
2 Orange	3.76	3.30	1.82	1.65	1.20	1.25
3 Brown	3.93	3.57	1.91	1.82	1.84	3.51
4 White	3.61	3.21	1.49	1.32	1.07	1.13
5 Slate	3.72	3.21	1.51	1.38	1.15	1.24
6 Green	4.51	3.87	2.98	1.65	1.35	1.25

Cable 7: 072081-4C-2

1 Blue	4.02	3.46	1.60	1.46	1.21	1.20
2 Orange	4.04	3.49	1.67	1.46	1.22	1.14
3 Brown	4.69	4.20	2.19	2.05	1.75	4.64
4 White	4.22	3.67	1.75	1.64	1.38	1.68
5 Slate	4.90	4.40	2.29	2.11	1.77	1.79
6 Green	4.01	3.57	1.83	1.75	1.49	1.48

Injected NA 0.089.

Table E-4. Attenuation Versus Injected NA After Temperature Shock
(Wavelength 820 nm).

Cable 2: 071881-4C-1

	Injection NA			
	<u>0.089</u>	<u>0.124</u>	<u>0.176</u>	<u>0.243</u>
<u>Fiber</u>				
1 Blue	4.56	4.74	4.52	4.74
2 Orange	4.01	3.97	4.16	4.30
3 Brown	3.83	3.79	3.83	3.84
4 White	3.56	3.56	3.84	3.88
5 Slate	3.58	3.68	3.97	3.82
6 Green	3.93	4.41	4.21	4.33

Cable 5: 072081-4C-1

1 Blue	3.73	3.74	4.02	4.11
2 Orange	3.84	3.62	3.69	3.97
3 Brown	3.75	3.57	3.81	3.70
4 White	3.81	3.94	4.15	4.29
5 Slate	4.03	3.94	4.27	4.28
6 Green	4.66	4.65	4.86	5.24

Table E-4. Attenuation Versus Injected NA After Temperature Shock
(Wavelength 820 nm) (continued).

Cable 6: 071681-4C-1

Fiber	Injection NA		
	<u>0.089</u>	<u>0.124</u>	<u>0.176</u>
1 Blue	4.05	4.00	4.26
2 Orange	3.76	3.69	3.90
3 Brown	3.93	4.01	4.06
4 White	3.61	4.22	3.82
5 Slate	3.72	3.75	3.83
6 Green	4.51	4.39	4.63
			<u>0.243</u>
			4.13
			4.00
			4.03
			4.00
			3.90
			4.62

Cable 7: 072081-4C-2

1 Blue	4.02	4.20	4.27	4.35
2 Orange	4.04	4.20	4.10	4.20
3 Brown	4.69	4.86	4.66	4.71
4 White	4.22	4.25	4.37	4.55
5 Slate	4.90	4.79	4.76	4.90
6 Green	4.01	4.18	4.21	4.40

Table B-5. Numerical Aperture (90% Power) After Temperature Shock.

Fiber	Cable Number											
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>
1 Blue		0.21			0.20	0.25	0.22					
2 Orange		0.24			0.21	0.24	0.22					
3 Brown		0.23			0.20	0.21	0.25					
4 White		0.25			0.22	0.23	0.21					
5 Slate		0.23			0.22	0.22	0.21					
5 Green		0.23			0.20	0.21	0.24					

APPENDIX F
FINISHED CABLE TEST DATA

14205a

F-1

Table P-1. Finished Cable Test Results, MMET Cables (Confirmatory).

CABLE	IMPACT TEST 3-FT-LB									
	ROOM TEMPERATURE					+71°C				
	S	BF	TS	S	BF	TS	S	BF	TS	-55°C
3 ⁶ 071001-4-2	6	0	100	0	6	0	100	0	6	6 85 0
5 ³ 072001-4-1	6	0	100	0	6	0	100	0	6	6 85 0
7 ¹ 072001-4-2	6	0	100	0	6	0	100	0	6	5 86 0
3 ⁶ 071001-4-2	6	0	100	0	6	0	100	0	6	0 100 0
5 ³ 072001-4-1	6	0	100	0	6	0	100	0	6	0 100 0
7 ¹ 072001-4-2	6	0	100	0	6	0	100	0	6	0 100 0
3 ⁶ 071001-4-2	6	0	100	0	6	0	100	0	6	0 100 0
5 ³ 072001-4-1	6	0	100	0	6	0	100	0	6	0 100 0
7 ¹ 072001-4-2	6	0	100	0	6	0	100	0	6	0 100 0
3 ⁶ 071001-4-2	6	0	100	0	6	0	100	0	6	0 100 0
5 ³ 072001-4-1	6	0	100	0	6	0	100	0	6	0 100 0
7 ¹ 072001-4-2	6	0	100	0	6	0	100	0	6	0 100 0

NOTES: S = NO OF SAMPLE TESTED
 BF = NO OF BROKEN FIBERS
 TS = JACKET SPLIT
 $95 \text{ BF} = \text{PERCENT OF SURVIVING FIBERS} = \frac{\text{SKE} - \text{BF}}{\text{SKE}} \times 100$

II-3.1 TENSILE LOAD

Cable 071881-4a-1 #3

Sample Length _____ in

Gage Length 26 in

Specification

Starting Tensile Load ($t=0$) 410 lb_f

400 min

(1 lb_f = 4.448 N) 1823 N

1780 min

Adjustments During Test

Approximate Time s	Initial Load lb _f	Adjusted Load lb _f
15	380	400
* 45	395	410

Finished Tensile Load ($t=60s$) 410 lb_f
Post Test Continuity 1825 N

Number of Continuous Fibers	Specification
6	6

Remarks: * Adjusted prematurely

Observed by Tom Armstrong

T. H. Armstrong 7/17/81

Gauge Calibrated 9/3/81

Pass ☒

Fail _____

Operator B. Fagis

Date 09/17/81

Government Witness _____

Date _____

II-3.1 TENSILE LOAD

Cable 072081-4c-1 #5

Sample Length _____ in

Gage Length 7.2 (5.6 x 2) in

Starting Tensile Load ($t=0$) ⁸²⁴²
= 410 lbf

(1 lbf = 4.448 N) 1823 N

Specification

400 min

1780 min

Adjustments During Test

Approximate Time s	Initial Load lbf	Adjusted Load lbf
15	380	410
50	380	405

Finished Tensile Load ($t=60s$) 402 lbf
 Post Test Continuity 1789 N

Number of Continuous Fibers	Specification
6	6

Remarks: _____

OBSERVED BY MIKE BOWMAN, Mf20111111

GLUE CHATILLON MODEL WT-10 SERIAL 4389 (1777817908)

Pass ☒ Fail _____

Operator R. FARIS

Date 8-26-81

Government Witness _____

Date _____

cable #7

II-3.1 TENSILE LOAD

Cable 072081-9C-2

Sample Length _____ in

Gage Length 7.36 (3.68x2) in

Specification

Starting Tensile Load($t=0$) 425 lb_f

400 min

(1 $lb_f = 4.448$ N) _____ N

1780 min

Adjustments During Test

Approximate Time s	Initial Load lbf	Adjusted Load lbf
10	850	—

Finished Tensile Load ($t=60s$) 370 lb_f
Post Test Continuity _____ N

Number of Continuous Fibers	Specification
6	6

Remarks: DC-202 10/16/81

Pass ☒

Fail ☐

Operator: Wheatley Khuanhena

Date 10/16/81

Government Witness _____

Date _____

APPENDIX G
TEMPERATURE CYCLING DATA

14205a

G-1

Table G-1. High and Low Temperature Test Results, Cable 1 and Cable 2.

Cable 1: 071781-4C-1

Fiber id	Attenuation (dB/km)		Dispersion (ns/km)		High Temp (Δ dB/km)		Low Temp (Δ dB/km)
	Before	After	Δ	Before	After	Δ	
1 Blue	3.65	3.09	-0.56	0.36	0.37	+0.01	1.60
2 Orange	3.65	3.25	-0.40	0.36	0.51	+0.15	4.77
3 Brown	3.14	3.07	-0.07	0.93	1.09	+0.16	3.90
4 White	2.94	2.55	-0.39	0.52	1.52	+1.00	0.87
5 Slate	3.43	3.15	-0.28	0.76	1.35	+0.59	2.55
6 Green	3.42	3.30	-0.12	0.33	0.52	+0.19	1.68
Average	3.37	3.07	-0.30	0.54	0.89	+0.35	2.56

Cable 2: 071881-4C-1

1 Blue	4.22	3.61	-0.61	0.94	1.08	+0.14	0.05	0.06	1.44
2 Orange	3.68	3.46	-0.22	0.77	0.80	+0.03	0.01	0.02	1.47
3 Brown	3.04	3.09	+0.05	0.72	0.78	+0.06	0.09	0.08	2.58
4 White	3.32	2.95	-0.37	0.84	1.01	+0.17	0.04	0.05	1.81
5 Slate	3.87	3.14	-0.73	1.39	1.20	-0.19	0.05	0.04	0.59
6 Green	2.84	3.29	+0.45	0.48	0.63	+0.15	0.01	0.00	2.03
Average	3.49	3.26	-0.23	0.85	0.91	+0.06	0.04	0.04	1.65

Table G-2. High and Low Temperature Test Results, Cable 3 and Cable 4.

Cable 3: 071881-4C-2

Fiber id	Attenuation (dB/km)		Dispersion (ns/km)		High Temp (Δ dB/km)		Low Temp (Δ dB/km)
	Before	After	Δ	Before	After	Δ	
1 Blue	3.29	3.23	-0.06	0.44	0.55	+0.11	10.12
2 Orange	3.15	3.40	+0.25	0.31	0.52	+0.21	5.72
3 Brown	3.34	3.15	-0.19	0.68	0.55	-0.13	2.72
4 White	3.20	3.56	+0.36	0.60	0.50	-0.10	2.03
5 Slate	3.23	4.11	+0.88	0.34	0.67	+0.33	1.50
6 Green	<u>3.47</u>	<u>3.93</u>	<u>+0.46</u>	<u>1.03</u>	<u>1.20</u>	<u>+0.17</u>	<u>1.43</u>
Average	3.28	3.56	+0.28	0.56	0.66	+0.10	3.93

Cable 4: 071881-4C-3

Fiber id	Attenuation (dB/km)		Dispersion (ns/km)		High Temp (Δ dB/km)		Low Temp (Δ dB/km)
	Before	After	Δ	Before	After	Δ	
1 Blue	3.52	3.65	+0.13	1.09	1.19	+0.10	2.85
2 Orange	3.74	3.72	-0.02	0.35	0.37	+0.02	2.95
3 Brown	3.13	3.25	+0.12	0.62	0.68	+0.06	2.52
4 White	3.40	3.18	-0.22	1.22	1.39	+0.17	5.54
5 Slate	3.44	3.34	-0.10	0.56	0.58	+0.02	3.10
6 Green	<u>3.31</u>	<u>3.42</u>	<u>+0.11</u>	<u>0.56</u>	<u>0.51</u>	<u>-0.05</u>	<u>1.33</u>
Average	3.42	3.42	0.00	0.73	0.78	+0.05	3.04

Table G-3. High and Low Temperature Test Results, Cable 5 and Cable 6.

Cable 5: 072081-4C-1

Fiber id	Attenuation (dB/km)		Dispersion (ns/km)		High Temp (Δ dB/km)		Low Temp (Δ dB/km)	
	Before	After	Δ	Before	After	Δ	+49°C	+71°C
1 Blue	4.53	4.27	-0.26	0.76	0.11	-0.65	0.02	0.02
2 Orange	3.50	3.50	0.00	1.37	1.21	-0.16	0.16	0.25
3 Brown	3.38	2.26	-1.12	1.46	1.52	+0.06	0.03	0.03
4 White	3.66	3.38	-0.28	0.98	0.92	-0.06	0.06	0.13
5 Slate	3.63	3.62	-0.01	1.61	1.24	-0.37	0.09	0.08
6 Green	3.43	3.39	-0.04	0.68	0.52	-0.16	0.04	0.03
Average	3.69	3.40	-0.29	1.14	0.92	-0.22	0.06	0.09

Cable 6: 071681-4C-1

1 Blue	3.21	3.30	+0.09	0.32	0.76	+0.44	0.04	0.06	12.65
2 Orange	3.14	3.50	+0.36	0.72	0.73	+0.01	0.08	0.13	6.59
3 Brown	3.08	3.45	+0.37	0.51	0.52	+0.01	0.08	0.15	2.93
4 White	2.82	4.14	+1.32	0.21	0.66	+0.45	0.08	0.11	3.62
5 Slate	2.94	3.08	+0.14	0.69	0.71	+0.02	0.02	0.01	3.47
6 Green	4.07	3.90	-0.17	0.65	0.74	+0.09	0.24	0.24	6.40
Average	3.21	3.56	+0.35	0.52	0.69	+0.17	0.09	0.12	5.94

Table G-4. High and Low Temperature Test Results, Cable 7 and Cable 8.

Cable 7: 072081-4C-2

Fiber id	Attenuation (dB/km)		Dispersion (ns/km)		High Temp (Δ dB/km)		Low Temp (Δ dB/km)
	Before	After	Δ	Before	After	Δ	
1 Blue	3.42	3.90	+0.48	1.00	0.97	+0.03	2.31
2 Orange	3.40	3.84	+0.44	1.22	1.26	+0.04	4.74
3 Brown	4.18	4.32	+0.14	0.37	0.44	+0.07	4.92
4 White	3.34	3.42	+0.08	0.87	1.22	+0.35	2.36
5 Slate	4.11	4.40	+0.29	0.69	1.02	+0.33	9.27
6 Green	3.73	4.32	+0.59	0.57	0.65	+0.08	2.70
Average	3.69	4.03	+0.34	0.79	0.93	+0.15	4.38

Cable 8: 082781-4C-1

1 Blue	3.31	4.07	+0.76	1.45	1.80	+0.35	0.05	0.09	1.28
2 Orange	2.95	2.81	-0.14	0.81	0.75	-0.06	0.60	0.74	4.77
3 Brown	3.29	3.06	-0.23	0.62	0.48	-0.14	0.14	0.19	2.04
4 White	3.62	3.46	-0.16	1.41	1.22	-0.19	0.07	0.12	3.48
5 Slate	3.94	3.32	-0.62	1.16	0.86	-0.30	0.22	0.43	1.38
6 Green	3.87	3.62	-0.25	0.66	0.74	+0.08	0.04	0.08	1.74
Average	3.50	3.40	-0.10	1.01	0.97	-0.04	0.18	0.27	2.44

Table G-5. High and Low Temperature Test Results, Cable 10 and Cable 12.

Cable 10: 091881-4C-2

<u>Fiber id</u>	<u>Attenuation (dB/km)</u>		<u>Dispersion (ns/km)</u>		<u>High Temp (ΔdB/km)</u>		<u>Low Temp (ΔdB/km)</u>
	<u>Before</u>	<u>After</u>	<u>A</u>	<u>Before</u>	<u>After</u>	<u>A</u>	<u>-55°C</u>
1 Blue	3.64	3.73	+0.09	1.05	0.95	-0.10	1.59
2 Orange	3.34	3.58	+0.24	1.00	1.71	+0.71	2.26
3 Brown	4.30	4.26	-0.04	0.43	1.16	+0.73	2.48
4 White	2.96	3.82	+0.86	1.04	1.08	+0.04	4.20
5 Slate	4.01	3.77	-0.24	0.52	0.58	+0.06	1.76
6 Green	<u>3.67</u>	<u>3.50</u>	<u>-0.17</u>	<u>1.49</u>	<u>1.49</u>	<u>0.00</u>	<u>1.62</u>
Average	3.65	3.77	+0.12	0.92	1.16	+0.24	2.31

Cable 12: 091781-4C-1

1 Blue	4.19	4.15	-0.04	0.70	0.39	-0.31	0.06	0.19	11.22
2 Orange	3.03	2.78	-0.26	1.20	0.78	-0.42	0.01	0.05	0.43
3 Brown	3.00	3.04	+0.04	0.72	0.31	-0.41	0.16	0.33	21.46
4 White	3.37	3.40	+0.03	0.70	0.78	+0.08	0.02	0.16	4.03
5 Slate	3.70	2.92	-0.78	1.18	1.04	-0.14	0.03	0.20	2.37
6 Green	<u>3.03</u>	<u>3.28</u>	<u>+0.25</u>	<u>0.71</u>	<u>0.52</u>	<u>-0.19</u>	<u>-0.06</u>	<u>0.04</u>	<u>3.84</u>
Average	3.38	3.26	-0.12	0.86	0.63	-0.23	0.04	0.16	7.22

Table G-6. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling.

Cable 1: 071781-4C-1

Fiber	Wavelength (nm)				
	820	850	1060	1100	1200
1 Blue	3.55	3.14	1.47	1.35	1.13
2 Orange	3.36	2.94	1.36	1.22	0.98
3 Brown	3.80	3.36	1.74	1.56	1.33
4 White	3.89	3.38	3.06	1.43	1.21
5 Slate	3.29	2.92	1.44	1.30	1.28
6 Green	3.80	3.36	1.67	1.56	1.28

Cable 2: 071881-4C-1

1 Blue	4.21	3.63	1.60	1.43	1.24	1.04
2 Orange	3.90	3.46	1.60	1.48	1.23	1.36
3 Brown	3.57	3.09	1.51	1.34	1.22	1.11
4 White	3.40	2.95	1.33	1.21	1.05	1.04
5 Slate	3.49	3.14	1.37	1.21	0.96	1.11
6 Green	3.75	3.29	1.49	4.13	1.57	1.08

Injected NA 0.089.

Table G-6. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling (continued).

Cable 3: 071881-4C-2

Fiber	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	3.68	3.23	1.60	1.46	1.22	1.17
2 Orange	3.79	3.29	1.61	1.43	1.43	3.35
3 Brown	3.78	3.26	1.56	1.41	1.19	1.22
4 White	3.90	3.30	1.53	1.35	1.03	0.94
5 Slate	3.63	3.12	1.46	1.34	1.08	1.13
6 Green	3.85	3.32	1.25	1.08	0.71	0.58

Cable 4: 071881-4C-3

1 Blue	4.22	3.63	1.74	1.61	1.30	1.30
2 Orange	4.21	3.73	1.93	1.76	1.47	1.55
3 Brown	3.69	3.24	1.50	1.29	1.01	0.99
4 White	3.86	3.36	1.50	1.37	1.16	1.26
5 Slate	3.92	3.42	1.76	1.64	1.42	1.41
6 Green	3.91	3.45	1.77	1.62	1.35	1.32

Injected NA 0.089.

Table G-6. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling
(continued).

Cable 5: 072081-4C-1

Fiber	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	4.64	4.27	2.54	2.38	2.05	2.08
2 Orange	4.02	3.50	1.70	1.53	1.93	1.18
3 Brown	3.24	2.26	1.48	1.54	1.30	1.22
4 White	3.86	3.38	1.64	1.51	1.23	1.19
5 Slate	4.05	3.62	1.66	1.53	1.25	1.21
6 Green	3.85	3.39	1.70	1.56	1.36	1.28

Cable 6: 071681-4C-1

1 Blue	3.90	3.30	1.55	1.39	1.16	1.19
2 Orange	3.78	3.50	1.71	1.57	1.79	1.22
3 Brown	3.95	3.45	1.85	1.60	1.65	3.50
4 White	4.59	4.14	2.38	2.21	2.09	2.04
5 Slate	3.59	3.08	1.37	1.25	1.03	1.03
6 Green	4.61	3.90	1.77	1.66	1.35	1.22

Injected NA 0.089.

Table G-6. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling
(continued).

Cable 7: 072081-4C-2

Fiber	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	3.95	3.37	1.49	1.31	1.06	0.99
2 Orange	4.07	3.56	1.67	1.57	1.27	0.80
3 Brown	4.71	4.28	2.31	2.16	1.83	1.86
4 White	3.85	3.32	1.43	1.35	1.14	1.49
5 Slate	4.71	4.13	2.06	1.89	1.54	1.52
6 Green	4.14	3.66	1.95	1.81	1.56	1.38

9-10

Cable 8: 082781-4C-1

1 Blue	4.66	4.07	2.54	2.24	2.29	3.96
2 Orange	3.35	2.81	1.38	1.22	0.96	1.00
3 Brown	3.77	3.06	1.51	1.32	1.01	1.11
4 White	3.71	3.46	1.52	1.46	1.18	1.13
5 Slate	4.01	3.32	1.42	1.31	1.01	1.14
6 Green	4.06	3.62	1.75	1.70	1.46	1.40

Injected NA 0.089.

Table G-6. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling
(continued).

Cable 10: 091881-4C-2

Fiber	Wavelength (nm)					
	820	850	1060	1100	1200	1300
1 Blue	4.45	3.73	1.79	1.58	1.30	1.32
2 Orange	4.00	3.58	1.84	1.85	1.59	1.63
3 Brown	4.73	4.26	2.47	2.32	2.04	1.99
4 White	4.34	3.82	1.88	1.40	1.09	1.10
5 Slate	4.03	3.77	2.04	1.95	1.66	1.66
6 Green	4.02	3.50	1.61	1.47	1.31	1.45

Cable 12: 091781-4C-1A

1 Blue	4.59	4.15	2.26	1.83	1.75	1.79
2 Orange	3.18	2.78	1.28	1.19	1.00	0.93
3 Brown	3.50	3.04	1.51	1.42	1.20	0.65
4 White	3.91	3.40	1.70	1.55	1.32	1.23
5 Slate	3.39	2.92	1.38	1.25	1.11	1.10
6 Green	3.74	3.28	1.73	1.56	1.13	1.15

Injected NA 0.089

Table G-7. Attenuation Versus Injected NA After Temperature Cycling
(Wavelength 820 nm).

Cable 1: 071781-4C-1

Fiber	Injection NA		
	<u>0.009</u>	<u>0.124</u>	<u>0.176</u>
1 Blue	3.55	3.34	3.09
2 Orange	3.36	3.13	2.58
3 Brown	3.80	3.89	4.04
4 White,	3.89	3.93	3.95
5 Slate	3.29	3.93	4.26
6 Green	3.80	3.69	3.99
			<u>0.243</u>
			2.80
			2.48
			4.19
			4.08
			3.33
			3.96

Cable 2: 071881-4C-1

1 Blue	4.21	4.33	4.48	4.44
2 Orange	3.90	3.89	4.05	4.25
3 Brown	3.57	3.70	4.61	3.68
4 White	3.40	3.47	3.60	3.74
5 Slate	3.49	3.50	3.63	3.78
6 Green	3.75	3.75	3.94	4.18

**Table G-7. Attenuation Versus Injected NA After Temperature Cycling
(Wavelength 820 nm) (continued).**

Cable 3: 071881-4C-2

Fiber	Injection NA			
	<u>0.089</u>	<u>0.124</u>	<u>0.176</u>	<u>0.243</u>
1 Blue	3.68	3.71	3.47	3.18
2 Orange	3.79	4.01	3.81	3.94
3 Brown	3.78	4.06	4.26	4.35
4 White	3.90	4.20	4.23	4.21
5 Slate	3.63	3.51	3.65	3.80
6 Green	3.85	4.01	4.11	4.37

Cable 4: 071881-4C-3

1 Blue	4.09	3.96	4.54	4.22
2 Orange	4.21	4.30	4.37	4.22
3 Brown	3.69	3.79	3.76	4.02
4 White	3.86	3.86	3.85	3.91
5 Slate	3.92	3.97	4.05	4.24
6 Green	3.91	4.12	4.15	4.21

**Table G-7. Attenuation Versus Injected NA After Temperature Cycling
(Wavelength 820 nm) (continued).**

Cable 5: 072081-4C-1

Fiber	Injection NA			
	<u>0.089</u>	<u>0.124</u>	<u>0.176</u>	<u>0.243</u>
1 Blue	4.64	4.49	4.48	4.33
2 Orange	4.02	4.08	4.21	4.23
3 Brown	3.24	6.94	3.40	3.53
4 White	3.86	3.76	3.92	4.08
5 Slate	4.05	4.02	4.11	4.06
6 Green	3.85	3.84	4.08	4.17

Cable 6: 071681-4C-1

1 Blue	3.90	4.03	4.03	4.11
2 Orange	3.78	3.93	4.16	4.42
3 Brown	3.95	3.98	4.10	4.36
4 White	4.59	4.50	4.17	4.20
5 Slate	3.59	3.53	3.63	3.90
6 Green	4.61	4.55	4.61	4.72

**Table G-7. Attenuation Versus Injected NA After Temperature Cycling
(Wavelength 820 nm) (continued).**

Cable 7: 072081-4C-2

Fiber	Injection NA		
	<u>0.089</u>	<u>0.124</u>	<u>0.176</u>
1 Blue	3.95	4.08	4.01
2 Orange	4.07	4.10	4.35
3 Brown	4.71	4.78	4.80
4 White	3.85	3.87	4.05
5 Slate	4.71	4.76	4.85
6 Green	4.14	4.19	4.26
			<u>0.243</u>
			4.38
			4.49
			4.87
			4.19
			4.89
			4.63

Cable 8: 082781-4C-1

1 Blue	4.66	4.57	4.77	4.62
2 Orange	3.35	3.71	3.65	3.85
3 Brown	3.77	4.05	4.27	3.91
4 White	3.71	3.80	4.18	4.16
5 Slate	4.01	3.79	4.22	4.08
6 Green	4.06	4.64	4.34	4.25

**Table G-7. Attenuation Versus Injected NA After Temperature Cycling
(Wavelength 820 nm) (continued).**

Cable 10: 091881-4C-2

Fiber	Injection NA		
	<u>0.089</u>	<u>0.124</u>	<u>0.176</u>
1 Blue	4.45	4.34	4.44
2 Orange	4.00	3.88	4.33
3 Brown	4.73	4.84	5.14
4 White	4.34	4.80	4.67
5 Slate	4.03	3.79	4.49
6 Green	4.02	4.22	4.14
			<u>0.243</u>
			4.53
			3.93
			5.25
			4.80
			4.54
			4.09

Cable 12: 091781-4C-1A

1 Blue	4.59	4.65	4.62	4.71
2 Orange	3.18	3.15	3.57	3.73
3 Brown	3.50	3.77	3.98	4.14
4 White	3.91	3.94	3.77	4.11
5 Slate	3.39	3.54	3.54	3.83
6 Green	3.74	3.55	3.80	3.85

APPENDIX H
DISTRIBUTION LIST

14205a

H-1

DISTRIBUTION LIST

Defense Technical Information Center
Attn: DTIC-TCA
Cameron Station (Building 5)
Alexandria, VA 22314
(12 copies)

Director
National Security Agency
Attn: TDL
Fort George G. Meade, MD 20755

Code R123, Tech Library
DCA Defense Comm Engrg Ctr
1860 Wiehle Avenue
Reston, VA 22090

Defense Communications Agency
Technical Library Center
Code 205 (P.A. Tolovi)
Washington, DC 20305

Office of Naval Research
Code 427
Arlington, VA 22217

GIDEP Engineering & Support Dept.
TE Section
P.O. Box 398
Norco, CA 91760

CDR, MIRADCOM
Redstone Scientific Info Center
Attn: Chief, Document Section
Redstone Arsenal, AL 35809

Commander
HQ Fort Huachuca
Attn: TEchnical Reference Div
Fort Huachuca, AZ 85613

Commander
US Army Electronic Proving Ground
Attn: STEEP-MT
Fort Huachuca, AZ 85613

Commander
USASA Test & Evaluation Center
Attn: LAO-CDR-T
Fort Huachuca, AZ 85613

Director
Naval Research Laboratory
Attn: Code 2627
Washington, DC 20375

Command, Control & Communications
Division Development Center
Marine Corps Development & Educ Comd
Quantico, VA 22134

Naval Telecommunications Command
Technical Library, Code 91L
4401 Massachusetts Avenue, NW
Washington, DC 20390

Rome Air Development Center
Attn: Documents Library (TILD)
Griffiss AFB, NY 13441

HDQA (DAMA-ARP/DR. F.D. Verderame)
Washington, DC 20310

Director
US Army Human Engineering Labs
Aberdeen Proving Ground, MD 21005

CDR, AVRADCOM
Attn: DRSAB-E
P.O. Box 209
St. Louis, MO 63166

Director
Joint Comm Office (TRI-TAC)
Attn: TT-AD (Tech Docu Cen)
Fort Monmouth, NJ 07703

Dir., US Army Air Mobility R&D Lab
Attn: T. Gossett, Bldg. 207-5
NASA Ames Research Center
Moffett Field, CA 94035

HQDA (DAM)-TCE)
Washington, DC 20310

Deputy for Science & Technology
Office, Assist Sec Army (R&D)
Washington, DC 20310

Commander, DARCOM
Attn: DRCDE
5001 Eisenhower Avenue
Alexandria, VA 22333

Galileo Electro-Optics Corp.
Galileo Park
Attn: L. Thompson
Sturbridge, MA 01518

Electronics Group of TRW, Inc.
401 N. Broad Street
Philadelphia, PA 19108

Valtec Corporation
Electro Fiber Optic Div
West Boylston, MA 01583

Belden Corporation
Technical Research Center
2000 S. Batavia Avenue
Geneva, IL 60134
Attn: Mr. J. McCarthy

Hughes Aircraft Company
Connecting Devices Division
17150 Von Karman Avenue
Irvine, CA 92714
Attn: Mr. J. Maranto

Harris Government Info Systems Div
P. O. Box 37
Melbourne, FL 32901

ITT Defense Communications Division
492 River Road
Nutley, NJ 07110
Attn: Dr. P. Steensma

GTE Sylvania Inc.
Communications System Division
189 B Street
Needham Heights, MA 02194
Attn: Mr. J. Concordia

Commander
Naval Ocean Systems Center
Code 8115
San Diego, CA 92152

Commander
Naval Avionics Facility
Code D831
Indianapolis, IN 46218
Attn: Mr. R. Katz

Commanding General
Wright-Patterson AFB, OH 45433
AFAL/AAD-3
Attn: Mr. E. Friar

Commander
Naval Ocean Systems Center
Code 4400
San Diego, CA 92152
Attn: Mr. R. Lebduka

Commander
Naval Ocean Systems Center
Attn: Library
San Diego, CA 92152

General Cable Corporation
160 Fieldcrest Avenue
Edison, NJ 08817
Attn: Mr. M. Tenzer

ITT Cannon Electric Div
666 East Dyer Road
Santa Ana, CA 92702
Attn: Mr. R. McCartney

Mitre Corp.
P. O. Box 208
Bedford, MA 01730
Attn: Mr. C. Kleekamp

Project Manager, MSCS
Attn: DRCPM-MSCS-JSPB
(Capt. E. Howe)
Fort Monmouth, NJ 07703

National Bureau of Standards
Electromagnetic Tech Div
Boulder, CO 80303
Attn: Dr. G. Day

Defense Logistics Agency
Attn: DESC-EMT (Mr. A. Hudson)
Dayton, OH 45444

Commander
Air Force Avionics Laboratory
Attn: AFAL/AAD-2 (Mr. K. Trumble)
Wright-Patterson AFB, OH 45433

Brand-Rex Company
Williamantic, OT 06226
Attn: Mr. T. Redmerski

CDR, US Army Signals Warfare Lab
Attn: DELSW-OS
Arlington Hall Station
Arlington, VA 22212

CDR, US Army Signals Warfare Lab
Attn: DELSW-AW
Arlington Hall Station
Arlington, VA 22212

Commander
US Army Logistics Center
Attn: ATCL-MC
Fort Lee, VA 22801

Commander
US Army Training & Doctrine Command
Attn: ATCD-TEC
Fort Monroe, VA 23651

Commander
US Army Training & Doctrine Command
Attn: ATCD-TM
Fort Monroe, VA 23651

NASA Scientific & Tech Info Facility
Baltimore/Washington Intl Airport
P. O. Box 8757
Baltimore, MD 21240

Project Manager ATACS
Attn: DRCPM-ATC
Fort Monmouth, NJ 07703

CDR, US Army Research Office
Attn: DRXRO-IP
P. O. Box 12211
Research Triangle Park, NC 27709

Director
U.S. Army Material Systems Anal Actr.
Attn: DRXSY-MP
Aberdeen Proving Ground, MD 21005

Advisory Group in Electron Devices
201 Varick Street, 9th Floor
New York, NY 10014

TACTEC
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Ketron, Inc.
Attn: Mr. Frederick Leuppert
1400 Wilson Bldg.
Arlington, VA 22209

R. C. Hansen, Inc.
P. O. Box 215
Tarzana, CA 91356

Times Fiber Comm, Inc.
358 Hall Avenue
Attn: Mr. A. Kushner
Wallingford, Conn. 06492

Bell Northern Research
P. O. Box 3511, Station C
Attn: Dr. J. Dalgleish
Ottawa, Canada K1Y 4H7

Commander
ERADCOM
Fort Monmouth, NJ 07703
Attn: DELET-D

Commander
ERADCOM
Fort Monmouth, NJ 07703
Attn: DELSD-L-S

Commander
CORADCOM
Fort Monmouth, NJ 07703
Attn: DRDCO-COM-D

Commander
CORADCOM
Fort Monmouth, NJ 07703
Attn: DRDCO-SEI

Commander
CORADCOM
Fort Monmouth, NJ 07703
Attn: DRDCO-COM-RM-a
(15 Copies)

Corning Glass Works
Telecommunications Prod Dept
Attn: W. Babcock
Corning, NY 14830

Seicor Optical Cables
631 Miracle Mile
Horseheads, NY 14845

Bunker-Ramo
Amphenol Div
33 East Franklin Street
Danbury, Connecticut 06810
Attn: Mr. J. Makuch